State of California
The Resources Agency
Department of Water Resources

INTERIM REPORT
SP-F10, TASK 1E

Oroville Facilities Relicensing
FERC Project No. 2100

APRIL 2003

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1.0 SUMMARY

To complete Task 1E of SP-F10, a literature review was conducted to determine suitable water temperature, dissolved oxygen concentration, depth, substrate, and water velocity for adult spring-run Chinook salmon holding habitat. Upon completion of the literature review, an analysis was conducted to determine the existence, location, and distribution of suitable holding habitat in the Feather River below Oroville Dam. Sixteen pools were sampled in four reaches of the Feather River to collect water temperature, dissolved oxygen concentration, and depth data to which published parameters could be compared.

Data collected during spring, summer and early fall 2002 indicate generally suitable water temperatures for adult spring-run Chinook salmon holding from the Fish Barrier Dam to Mathews Riffle (RM 67 to RM64), with water temperatures increasing to reported sublethal and incipient lethal levels with increased distance downstream. At all sample sites, dissolved oxygen concentration was suitable for adult holding spring-run Chinook salmon on all sample dates. Pools of suitable depth are available during the holding period; however, not all pools sampled were of suitable depth throughout the entire holding period.

The initial results suggest that a larger temperature data set is needed to accurately draw conclusions about the availability, location, and distribution of suitable spring-run Chinook salmon holding habitat. In addition, it is expected that the description of adult Chinook salmon holding habitat use and subsequent spawning status portion of SP-F10 Task 1E, will be completed for upmigration and spawning periods, and subsequently will be integrated into the final report.

2.0 PURPOSE

The purpose of Task 1E of Study Plan (SP)-F10 is to identify and characterize adult spring-run Chinook salmon (*Oncorhynchus tshawytscha*) holding habitat in the Feather River below the Thermalito Diversion Dam. On September 19, 1999, naturally-spawned Central Valley spring-run Chinook salmon were listed as threatened under the federal Endangered Species Act (ESA) by the National Marine Fisheries Service (NMFS) (NMFS 1999). The Central Valley spring-run Chinook salmon ESU includes all naturally-spawned populations of spring-run Chinook salmon in the Sacramento River and its tributaries, which includes naturally-spawned spring-run Chinook salmon in the Feather River (NMFS 1999).

In addition to the ESA, Section 4.51(f)(3) of 18 CFR requires reporting of certain types of information in the Federal Energy Regulatory Commission (FERC) application for license of major hydropower projects, including a discussion of the fish, wildlife, and botanical resources in the vicinity of the project (Code of Federal Regulations 2001). The discussion is required to identify the potential impacts of the project on these resources, including a description of any anticipated continuing impact from on-going and future operations. As a subtask of SP-F10, *Evaluation of Project Effects on Salmonids and their Habitat in the Feather River Below the Fish Barrier Dam*, Task 1E fulfills a portion of the FERC application requirements by identifying and characterizing adult spring-run Chinook salmon holding habitat including physical habitat components such as water temperature, dissolved oxygen, and substrate within pools in the Feather River below the Thermalito Diversion Dam. In addition to fulfilling these requirements, the conclusions from this analysis may be used as the basis for developing or evaluating potential Protection, Mitigation and Enhancements (PM&Es) focused on adult spring-run Chinook salmon holding habitat in the Feather River.

Performing this subtask is necessary, in part, because operations of the Oroville Facilities affect Feather River flows, water temperatures, and channel morphology below Oroville Dam in a manner that may affect fish habitat. The Oroville Facilities regulate flow and water temperature below Oroville Dam (DWR 2001). Flow and water temperature manipulations resulting from operation of the Oroville Facilities may affect the quality, quantity, and distribution of spring-run Chinook holding habitat below Oroville Dam. In addition, alteration in sediment recruitment in the Feather River channel below Oroville Dam may result in depletion of gravel and sand and armoring of cobble and boulder substrates (DWR 2001). The current and future distribution of these substrate types also has the potential to affect the quality, quantity, and distribution of spring-run Chinook salmon holding habitat.

Ongoing operation of the Oroville Facilities influences flows and water temperatures in the Feather River downstream of the Thermalito Diversion Dam. Water temperatures and flow are both important factors influencing the ability of adult salmonids to migrate upstream and hold in natal streams until spawning occurs. Task 1 of SP-F10 evaluates the effects of Feather River water temperatures and flow on immigrating and holding adult Chinook salmon in the Feather River. Tasks 1A and 1C evaluate flow-related effects on immigrating adult salmonids. Task 1A evaluates the effects of Feather River flows on attraction of migrating salmonids, and Task 1C evaluates the effects of flow on potential physical passage impediments to adult salmonid immigration. Tasks 1B, 1D, and 1E evaluate the effects of water temperatures on adult salmonids. Task 1B evaluates the effect of water temperatures on attraction of migrating salmonid adults, while Task 1D evaluates the effects of water temperatures on pre-spawning adult salmonids and subsequent reproduction. Task 1E, herein, evaluates the effects of water temperatures on early upstream migrating (spring-run) adult Chinook salmon holding habitat and use patterns. For further description of Tasks 1A, 1B, 1C, or 1D relating to adult salmonid immigration, see SP-F10 and associated interim and final reports.

3.0 BACKGROUND

3.1 STUDY AREA

The upstream extent of the study area for this evaluation is the Thermalito Diversion Dam, and the downstream extent of the study area is the confluence of the Feather and Sacramento rivers. This geographic range within the Feather River encompasses the area potentially used as holding habitat by adult spring-run Chinook salmon prior to spawning in the Feather River. The reach of the study area from the Thermalito Diversion Dam to the Fish Barrier Dam consists of the Fish Barrier Pool. The reach of the Feather River extending from the Fish Barrier Dam to the Sacramento River is composed of two operationally distinct segments. The upstream segment extends from the Fish Barrier Dam at river mile (RM) 67.25 to the Thermalito Afterbay Outlet (RM 59), while the downstream segment extends from the Thermalito Afterbay Outlet (RM 59) to the confluence of the Feather and Sacramento Rivers (RM 0). The flow and water temperature regimes associated with each of these segments are distinct, and are summarized below.

Minimum flows in the lower Feather River were established in the August 1983 agreement between the California Department of Water Resources (DWR) and the California Department of Fish and Game (DFG) (DWR 1983). The agreement specifies that DWR release a minimum of 600 cubic feet per second (cfs) into the Feather River from the Thermalito Diversion Dam for fisheries purposes. Therefore, the reach of the Feather River extending from the Fish Barrier Dam to the Thermalito Afterbay Outlet is operated at 600 cfs year round, with variations in flow occurring infrequently. Most flow deviations from 600 cfs occur during flood control releases, or in the summer in order to meet downstream temperature requirements for salmonids, or for maintenance or monitoring purposes. Because this reach of the Feather River is supplied directly by water taken from Lake Oroville's hypolimnion that is selected in order to meet Feather River Hatchery and other downstream water temperature requirements, water temperatures in this reach of the Feather River are typically lower than temperatures in the downstream reaches.

Unlike the constant flow regime in the upstream segment of the Feather River, the flow regime in the reach of the Feather River extending from the Thermalito Afterbay Outlet (RM 59) to the confluence of the Feather and Sacramento rivers (RM 0) varies depending on runoff and month. Minimum flow requirement in this reach of the Feather River range from 1,000 to 1,700 cfs, depending upon the percentage of normal runoff and the month. Although the minimum flow requirements range from 1,000 to 1,700 cfs, flow in the reach of the Feather River extending from the Thermalito Afterbay Outlet to the confluence of the Feather and Sacramento rivers typically ranges from the minimum flow requirement up to 7,500 cfs (DWR 1982). Flow in this reach is, therefore, more highly varied than flow in the upstream segment. Flow in the downstream segment is additionally influenced by small flow contributions from Honcut Creek (RM 44) and the Bear River (RM 13), and by larger flow contributions from the Yuba River (RM 29). Water temperature in the reach of the Feather River extending from the Thermalito Afterbay Outlet to the confluence with the Sacramento River is typically warmer than water temperature in the upper reaches of the Feather River. Water temperature in this lower reach is directly influenced by the water releases from the Thermalito Afterbay Outlet. Because the Thermalito Afterbay is a large, shallow, warming basin, water that is released from the Thermalito Afterbay Outlet is typically warmer than the water originating from the upstream reach of the main channel of the Feather River. Typically, the contribution to the total flow in the Feather River from the Thermalito Afterbay Outlet is generally greater than flow contribution from the upper reach of the Feather River, and water temperatures in the river downstream of the Thermalito Afterbay Outlet are generally warmer than water temperatures in the reach upstream of the Thermalito Afterbay Outlet. For the purpose of this analysis, the study area is broken down into four reaches: the Fish Barrier Dam to Mathews Riffle (RM 67 to RM 64); Mathews Riffle to Thermalito Afterbay Outlet (RM 64 to RM 59); Thermalito Afterbay Outlet to Honcut Creek (RM 59 to RM 44); and Honcut Creek to the confluence of the Feather River with the Sacramento River (RM 44 to RM 0).

In addition, each reach was numbered from upstream to downstream beginning with the reach from the Fish Barrier Dam to Mathews Riffle. This reach was designated Reach 1. Within each reach, pools were labeled numerically from upstream to downstream. For example, the most upstream pool that was sampled was designated Pool 1-1 while the most downstream pool for which data was collected was designated Pool 4-5.

3.2 SPRING-RUN CHINOOK SALMON LIFE HISTORY

Historically, spring-run Chinook salmon were reported to have ascended to the very highest streams and headwaters in the Feather River watershed (DFG 1998). Currently, the Fish Barrier Dam below Oroville Dam restricts fish passage to historic spawning grounds at higher elevations (DFG 1998). Spring-run Chinook salmon exhibit a stream-type life history. Adult salmon reportedly enter their natal tributaries as sexually immature fish and hold in the river over the summer while gonadal maturation takes place (DFG 1998; DWR et al. 2000; Moyle 2002). It has been reported in the Feather River that adult spring-run Chinook salmon enter the river from March through June (Sommer et al. 2001). The holding period extends from the time that adult salmon reach their spawning areas until the onset of spawning, reportedly from August through October (DFG 1998; DWR et al. 2000; Moyle 2002). Therefore, in the Feather River, holding is assumed to occur from the time that spring-run Chinook salmon enter the river (March) through spawning (October).

3.3 HABITAT REQUIREMENTS

During the holding period (March through October), pools reportedly need to be sufficiently deep, cool, and oxygenated to allow over-summer survival of spring-run Chinook salmon (DWR et al. 2000). In general, Moyle (2002) reports that spring-run Chinook salmon select pools that are usually greater than two meters (6.6 ft) deep, typically with bedrock bottoms and water velocities ranging from 15-80 cm/sec (0.49-2.6 ft/sec). Adult spring-run Chinook salmon reportedly utilize overhanging ledges, deep pockets, and “bubble curtains” created by high velocity inflow as cover during the day (DFG 1998; DWR et al. 2000; Moyle et al. 1995; Moyle 2002). It also has been reported that holding fish utilize “pocket water” behind large rocks as velocity refuges in faster moving water (Moyle et al. 1995; Sommer et al. 2001). During the holding period, adult fish reportedly do not necessarily stay in one pool throughout the summer, but move between pools, generally with a net upstream movement (Moyle 2002). Pools are generally reported to be located near spawning areas, which may be at the tails of holding pools (DFG 1998; DWR et al. 2000; Moyle 2002).

3.4 THERMAL STRATIFICATION

Because suitable spring-run Chinook salmon holding habitat includes pools greater than two meters (6.6 feet) deep, the possibility exists in the Feather River of individuals selecting the deepest parts of otherwise unsuitably warm pools as thermal refugia if the pools stratify vertically. Studies conducted on streams in northern California including the Eel River, Redwood Creek, and Rancheria Creek indicate that thermal stratification in pools occurs under several conditions (Nielsen et al. 1994). In Redwood Creek and Rancheria Creek, thermal stratification in pools occurred under similar conditions, while conditions under which stratification occurred in the Middle Fork Eel River were somewhat different from the other two creeks. The gradients of Redwood Creek and Rancheria Creek were 0.18 % and <0.1 % respectively. The study reaches in the Middle Fork Eel Rived were comparatively steep (gradients exceeded 2 %). A single parameter that was similar for all three rivers was that all were characterized by low summer flows. The Middle Fork Eel River flows reportedly decreased to 0.1 cubic meters per second (3.5 cfs) during the 1990 drought. The minimum discharge in Redwood Creek was 0.8 cubic meters per second (28.3 cfs) in 1985, and mean summer discharge in Rancheria Creek is reported to be 2.1 cubic meters per second (74.2 cfs) (Nielsen et al. 1994). Other factors that reportedly contributed to water temperature stratification on Redwood and Rancheria creeks included encroachment of gravel bars into pools and inflow from one or more coldwater source including groundwater seepage, tributary inflow, and intergravel flow (Nielsen et al. 1994). Stratification of pools in the Middle Fork Eel River occurred without the apparent influence of a source of coldwater inflow or structural elements that isolated pool water from inflow. In this river, pools reportedly became stratified by virtue of the low intensities of turbulence, resulting from low summer discharge relative to the size of the channel (Nielsen et al. 1994). Because rivers that develop stratified pools are characterized by low flows and because the lowest flows in the Feather River are 600 cfs, it is unlikely that stratification could occur in potential holding pools in the Feather River.

3.5 POOL SELECTION CRITERIA

During data collection activities for SP-G2, habitat types within the study area downstream of the Fish Barrier Dam were characterized and mapped. Defining characteristics of pools included relatively low gradient with substrate of fine materials, relatively low water velocities, relatively high depth, tranquil flow, and section-controlled geomorphology. Pools sampled in the Feather River exhibited these characteristics, although many of them did not have a “scoured bowl” shape that is often considered typical holding habitat for adult spring-run Chinook salmon. (pers. com., S. McReynolds, DWR, 2003). It is anticipated that data collected from the habitat utilization portion of Task 1E will elucidate the actual use of pools in the Feather River by holding adult spring-run Chinook salmon.

3.6 SPRING-RUN CHINOOK SALMON MIGRATION TIMING

Very little data exists to elucidate trends in habitat use and temporal distribution of early upmigrant adult Chinook salmon in the Feather River. This is partly due to the fact that no consistent, long-term monitoring program has been implemented on the river. One study designed to assess the accuracy of carcass counts also assessed the timing of upmigrating Chinook salmon from 1969 through 1971. Fish longer than 26 inches total length were collected via a weir placed approximately 1.5 miles above the Thermalito Afterbay Outlet. These data show numbers of adult upmigrant Chinook from August 1969 through January 1970, from August 1970 through December 1970, and from August 1971 through December 1971 (Painter et al. 1977). Due to the temporal overlap between upmigrating spring-run and fall-run Chinook salmon, these data do not specifically elucidate the temporal distribution of adult spring-run Chinook salmon migrants. Another study performed in 1968 and 1969 attempted to find hatchery holding areas where adult spring-run Chinook salmon could be successfully held over the summer. The hatchery gates were opened for various periods between May 12, 1968 and July 31, 1968 as well as between April 1 and May 20, 1969. During 1968, 90 fish were counted entering the hatchery and during 1969, 112 fish entered the hatchery. The study was not continued due to high mortality rates of holding fish in the hatchery (Painter et al. 1977). Although the study demonstrated the difficulty in holding adult Chinook salmon over the summer in the hatchery, it also showed that adult Chinook salmon have been in the vicinity of the hatchery as early as April 1. However, the short time period and lack of consistency between data collected in 1968 and 1969 do not allow for analysis of trends in adult spring-run Chinook salmon upmigrant timing.

3.7 EXPECTED RESULTS

As described above, little quantitative information exists regarding the temporal or spatial distribution of spring-run Chinook salmon in the Feather River. Observations by DFG fisheries biologists suggest that most early upmigrant Chinook salmon adults typically hold in the upper three miles of the reach of the Feather River extending from the Fish Barrier Dam to the Thermalito Afterbay Outlet (DWR et al. 2000). Based on existing anecdotal information and observations regarding the distribution of holding adult Chinook salmon in the Feather River, it is expected that the water temperature in sampled pools between the Fish Barrier Dam and Mathews Riffle will be within the range of suitable water temperatures for adult spring-run Chinook salmon holding throughout the adult migration and holding period (March – October). Between Mathews Riffle and the Thermalito Afterbay Outlet, it is expected that water temperatures in sampled pools will be within the range of suitable water temperatures for adult spring-run Chinook salmon holding during portions of the migration period. It is within this reach that it is expected that the water temperatures of some pools will exceed the range of suitable water temperatures for adult spring-run Chinook salmon holding during some portions of the holding period. If the initial water temperature data supports this hypothesis, the data may not be sufficient to provide the exact location and time at which water temperatures exceed the range of suitable water temperatures for adult spring-run Chinook salmon holding. It is anticipated that additional data collection may be required to determine where and when water temperatures can exceed the range of suitable water temperatures for adult spring-run Chinook salmon holding. Due to the variable flow regimes and typically increased water temperatures below the Thermalito Afterbay Outlet, it is expected that water temperatures in sampled pools downstream of the Thermalito Afterbay Outlet will generally exceed the range of suitable water temperatures for adult spring-run Chinook salmon holding for the majority of the holding period. Although water temperatures in potential adult spring-run Chinook salmon holding pools are expected to exceed the range of water temperatures for extended holding, it is not expected that a thermal barrier to adult upstream migration is present during the migration or holding period in the Feather River. It has been reported that migrating adult Chinook salmon can tolerate temperatures up to 25º C to 27º C for transient periods (Marine 1992).

3.8 COMPARISON BETWEEN INTERIM AND FINAL REPORT

This interim report serves to examine existing data and recommend the location and intensity of future sampling efforts in order to accurately identify and characterize adult spring-run Chinook salmon holding pool habitat as set forth in Task 1E, *Identify and Characterize Early Up-Migrant Adult Chinook Salmon Holding Habitat and Habitat use Patterns*, of SP-F10. It is intended that the final report will include an analysis of the quantity, quality, and distribution of suitable habitat. In addition, a related but separate component of Task 1E of SP-F10 sets out a plan of action to assess the habitat use patterns of adult early upmigrant Chinook salmon holding in the Feather River. Although the habitat utilization component of Task 1E is not part of this interim report, the results will be integrated into the final report.

4.0 METHODOLOGY

One objective of Task 1E of SP-F10 is to identify and characterize adult spring-run Chinook salmon holding habitat. Potential holding pools between the Thermalito Diversion Dam and Honcut Creek were to be identified using existing DWR habitat maps. Because previous observations suggested that most adult early upmigrant Chinook salmon hold in the three miles of the Feather River immediately downstream from the Fish Barrier Dam (DWR et al. 2000), the water temperature profile of every pool from the Thermalito Diversion Dam (RM 67) to Mathews Riffle (RM 64) was to be determined during the first year of data collection. The Thermalito Diversion Dam was chosen as the upstream extent of holding habitat characterization because of the potential to allow salmonids to hold in the Fish Barrier Pool if the habitat upstream to the Thermalito Diversion Dam is suitable for holding. Water temperatures in the lower portion (i.e. below Mathews Riffle) of the reach that extends from the Thermalito Diversion Dam to the Thermalito Afterbay Outlet (RM 59) are generally warmer than the water temperatures in the upper portion of this reach (DWR et al. 2000). As a result, holding habitat in downstream from Mathews Riffle may be less suitable for adult Chinook salmon holding than the upstream portion of the reach. Therefore, water temperature profiles in half of the pools (50%) in the reach between Mathews Riffle and the Thermalito Afterbay Outlet were to be determined initially. The pools were to be stratified according to dimensions and a random sample was to be taken within each stratum. If there were not sufficient differences in pool dimensions to allow for stratification, the selection of pools was to be random within this reach. Because water releases from the Thermalito Afterbay cause warmer water temperatures downstream of the Thermalito Afterbay Outlet, the most suitable holding habitats are likely upstream of the Thermalito Afterbay Outlet (DWR and USBR 2000). Based on water temperature modeling efforts conducted on the Feather River for DWR and USBR's Biological Assessment of the effects of the CVP and SWP on Chinook salmon exhibiting spring-run life-history, it was concluded that for 2000 and 2001, it was unlikely that adult Chinook salmon would use the portion of the Feather River below the Thermalito Afterbay Outlet except as a migration corridor to the upper reaches of the river (DWR et al. 2000). However, fieldwork was initiated to determine whether or not the pools downstream of the Thermalito Afterbay Outlet do provide water temperatures suitable for holding adult Chinook salmon. Pools were to be identified and placed into strata according to pool dimensions as described above, and initially 25% of the pools between the Thermalito Afterbay Outlet and Honcut Creek were to be sampled according to random selection within each stratum. The same pools were to be sampled each month throughout the first field season.

After the first year of study, results were to be summarized and evaluated to determine if the level of survey effort should be re-focused. For example, if initial results suggest that water temperatures are suitable in all deep pools upstream of Mathews Riffle throughout the summer, the following field season fewer pools upstream of Mathews Riffle could be sampled and more effort could be focused on investigating pools downstream where temperatures are closer to the temperature ranges reported to be suitable for holding adult chinook salmon.

Once selection of the pools was completed, water temperatures were to be measured at half-meter intervals in deep pools bi-weekly from March through October, as specified in SP-W6, Task 1A. In addition to characterization of water temperatures, substrate and cover data were to be collected during the first water temperature survey of the year. Dominant substrate size was to be assessed visually using the Brusven index system currently in use by DWR (see Table 1, Task 3A of SP-F10). Cover data was also to be collected during the snorkel surveys using the currently used DWR cover codes (see SP-F10, section 7.0 Coordination and Implementation under SP-G2).

The Study Plan for Task 1E of SP-F10 originally specified the analysis detailed above. With the exception of changes in sampling regime and in collection of data describing cover and substrate in potential holding pools, the remainder of the analysis was conducted in accordance with the original study plan proposal. A detailed description of the analytical procedures utilized in the analyses is provided below.

4.1 DEFINITION OF HOLDING PERIOD

The holding period extends from the time that adult Chinook salmon enter their natal stream until the onset of spawning. In the Feather River, the holding period was assumed to occur from March through October based on analysis of reported Chinook salmon arrival times in the Feather River (Sommer et al. 2001) and general dates provided for the onset of reported spring-run Chinook salmon spawning. Generally, it has been reported that spring-run Chinook salmon spawning occurs from mid to late August through October (DFG 1998; DWR et al. 2000; Moyle 2002). The end of October was used in this analysis as the end of the holding period because it was assumed that all spring-run Chinook have begun spawning by then, and therefore spring-run Chinook salmon would not be holding after October.

4.2 DEFINITION OF SUITABLE WATER TEMPERATURE RANGE FOR ADULT SPRING-RUN CHINOOK SALMON HOLDING

The first step in identifying and characterizing spring-run Chinook salmon holding habitat was to compile data on suitable water temperatures for pre-spawning adults. The status review of spring-run Chinook salmon in the Sacramento River Drainage published by DFG (1998) suggests that... “the upper limit of the optimal temperature range for adults holding while eggs are maturing is 59º F to 60º F (Hinze 1959)”. These water temperatures correspond to 15º C to 15.6º C. However, the Hinze (1959) report did not specifically address water temperature requirements for holding adult spring-run Chinook salmon. Rather, that report examined variable water temperature exposures of adult and incubating eggs of fall-run Chinook salmon. Conventional salmon hatchery practice is reported to consider salmon broodstocks thermally stressed above 15º C (McCullough 1999). In his extensive literature review of the effects of changes in water temperature regimes on various lifestages of Chinook salmon, McCullough (1999) presents evidence that thermal stress causes increased adult mortality, increased incidence of disease among adults, and increased egg mortality for progeny of adults holding at high temperatures. Reportedly, laboratory tests confirm that temperatures above 21º C equal or exceed incipient lethal temperatures for Columbia River Chinook salmon stocks migrating in the summer (McCullough 1999). Berman 1990 (*in*

McCullough 1999) showed no mortality from Columnaris disease in spring-run Chinook salmon taken from the Yakima River and held for 1.5 months at 14º C, while 100% mortality occurred from infection in those held at 19º C. In a subsequent experiment, Berman (1990 *in* McCullough 1999) showed that pre-spawning adults that were held between 17.5º C and 19 Cº for two weeks prior to spawning had increased pre-hatch mortality and decreased alevin size compared to a control group held between 14.5º C and 15º C. Williams and others (2002) report that there is evidence that the historic population of spring-run Chinook salmon in the San Joaquin River was unusually tolerant of high water temperatures during the holding period, and that they held in pools with water temperatures that reached 22.7 ºC. Based on the output of a habitat suitability index model, Raleigh and others (1986) suggested that the maximum suitability for pre-spawning adult Chinook salmon is when water temperatures range between 8º C and 12º C (Raleigh et al. 1986). Marine (1992) reports water temperature ranges for a variety of effects on adult Chinook salmon. A range of 6º C to 14º C was reported for optimal pre-spawning broodstock survival, maturation, and spawning (Marine 1992). It has been suggested, however, that spring-run Chinook salmon in Butte Creek routinely hold in pools with mean daily temperatures that often exceed 20º C (Williams et al. 2002). Mean water temperatures in spring-run Chinook salmon holding pools in Mill Creek, Tehama County, was reported to be 20º C (18.3º C – 21.1º C) during the summer of 1986 (Moyle et al. 1995).

Due to the wide range of reported suitable temperatures for adult spring-run Chinook salmon holding, selection of a single number to which collected data can be compared to satisfy the objective of Task 1E does not seem prudent. Marine (1992) performed a literature search in conjunction with extensive interviews of hatchery managers and agency personnel and concluded that sublethal effects of chronic pre-spawning exposure to elevated water temperatures on reproductive performance may likely begin to occur within the temperature range of 15º C to 17º C. In addition, Marine (1992) concluded that for chronic exposures, an upper incipient lethal temperature limit for pre-spawning adult salmon probably falls within the range of 17º C to 20º C. This study was chosen as the basis for analysis of potentially suitable holding pools for adult spring-run Chinook salmon in the Feather River because it provided temperature ranges for optimal survival, maturation and spawning, for sublethal effects of chronic exposure, and for incipient upper lethal temperatures. In addition, Marine (1992) interviewed hatchery and agency personnel in the Sacramento River Basin and in other parts of California; thus, his temperature ranges may be more representative for Feather River fish than those temperatures provided in the literature for fish in other latitudes, such as the Yakima River in Washington, reported in McCullough (1999). Bell (1991) indicated that latitudinal differences in temperature tolerances were approximately equal to one degree F for each degree change in latitude (Bell 1991). Due to the range of temperatures reported by Marine (1992), the endpoints of the range (e.g., 15º C and 17º C for sublethal effects of chronic exposure) were used as indicators at which effects could potentially occur on fish holding in the Feather River. The resultant temperature indices were then compared to data collected by DWR for SP-W6 to identify and characterize potential holding habitat within the Feather River.

4.3 DEFINITION OF SUITABLE DISSOLVED OXYGEN FOR ADULT SPRING-RUN CHINOOK SALMON HOLDING

Although suitable dissolved oxygen (DO) concentration ranges have not been specifically reported for holding adult spring-run Chinook salmon, the US Environmental Protection Agency reports that the thirty-day mean water column DO concentration for protection of adult lifestages of coldwater fish species is 6.5 mg/L (EPA 2002). The thirty-day mean value was used because it is the most conservative value provided for post-juvenile lifestages. Single-day minimum (4.0 mg/L) and seven-day mean minimum (3.0 mg/L) criteria were both less stringent than the thirty-day mean value provided by the EPA as minimum DO concentrations suitable for coldwater aquatic life (EPA 2002). Therefore, for the purpose of this analysis, DO concentrations exceeding 6.5 mg/L were considered suitable for adult spring-run Chinook salmon holding.

4.4 DEFINITION OF SUITABLE SUBSTRATE FOR ADULT SPRING-RUN CHINOOK SALMON HOLDING

Little data exists describing the composition of suitable substrates for holding adult spring-run Chinook salmon. DFG (1998) suggests that adult spring-run Chinook salmon prefer deep pools that have bedrock bottoms and that holding salmon tend to avoid cobble, gravel, sand, and silt substrates. Others suggest that although holding pools generally have bedrock bottoms, suitable holding habitat depends on the pool volume, pool depth, amount of available cover, and proximity to spawning gravel (Moyle et al. 1995).

Based on the current and historic distribution of holding spring-run Chinook salmon populations, it is possible that reported substrate preferences were simply observations of habitat utilization rather than actual descriptions of preferred substrate types. Adult spring-run Chinook salmon historically held in the headwaters of natal stream systems and current distribution information suggests that they migrate as far upstream as possible before holding (DFG 1998). Oftentimes those reaches are located in bedrock canyons. It has been reported, for example, that the reach in Butte Creek in which holding occurs, suitable water temperatures, and velocities occur in pools which also have bedrock bottoms (Butte Creek Watershed Conservancy 2003). As such, it is not possible to definitively determine a causal relationship between substrate composition and holding pool preference because of the influence of other explanatory variables such as water temperature.

Because of a lack of definitive evidence to suggest that substrate composition is a defining factor in habitat suitability for holding adult spring-run Chinook salmon, the substrate composition data collected by SP-G2 will not be analyzed to determine suitability of pools for holding in the Feather River. Instead, substrate data collected by SP-G2 will be used in conjunction with data on actual pool use collected during the habitat utilization study to determine whether correlations exist between substrate composition and pool utilization.

4.5 DEFINITION OF SUITABLE COVER FOR ADULT SPRING-RUN CHINOOK SALMON HOLDING

Moyle and others report that suitable cover is required for spring-run Chinook salmon holding habitat (DFG 1998; DWR et al. 2000; Moyle et al. 1995; Moyle 2002). Because adult spring-run Chinook salmon do not eat and have no natural predators once they begin upstream migration, it is not known to what extent cover is important. It has been reported that holding salmon use pocket water as velocity refuges and seek shade under rocky ledges while holding (Moyle et al. 1995; Moyle 2002). In holding areas where velocities are low enough that salmon need not seek refuge and where water temperatures are cool enough to sufficiently slow metabolic activity, it is possible that cover is not a requirement for holding pool suitability.

In the Feather River, few pools exist with the types of cover (bubble curtains, rocky ledges, pocket water, etc.) described in the literature as preferred by holding spring-run Chinook salmon. Because spring-run Chinook salmon do hold in the Feather River, it is necessary to determine whether correlations exist between cover availability and habitat use. Cover data will be collected with substrate data and analyzed with the habitat utilization data to determine if a correlation exists between cover availability and pool use in the Feather River.

4.6 DEFINITION OF SUITABLE WATER VELOCITIES FOR ADULT SPRING-RUN CHINOOK SALMON HOLDING

Suitable water velocities are reported to be an important criterion in determining suitable holding pool habitat. A range of 0.5–1.3 ft/sec has been reported by DFG and DWR (DFG 1998; DWR et al. 2000). Moyle (2002) reports that in California, spring-run Chinook salmon usually hold in water column velocities between 15 and 80 cm/sec (0.49-2.6 ft/sec) (Moyle 2002). Moyle and others (1995) reported that in Deer Creek, Tehama County, in 1988, holding adult spring-run Chinook salmon preferred water velocities between 60 and 80 cm/sec (2-2.6 ft/sec). Additionally, Moyle and others (1995) reported that other authors suggest that optimal velocity ranges between 15 and 37 cm/sec (0.49-1.2 ft/sec).

It is unknown whether pools within the Feather River contain suitable velocities for holding adult Chinook salmon. If the data become available for the 2003 sampling season (March through October) then analysis can be performed to determine whether suitable velocities exist within the Feather River. In addition, once the data become available from the habitat utilization portion of Task 1E, correlations can be made between habitat use and pool water velocities.

4.7 WATER TEMPERATURE AND DISSOLVED OXYGEN DATA COLLECTION IN FEATHER RIVER POOLS

In order to identify and characterize spring-run Chinook salmon holding pool habitat, water temperature, DO, and water depth data were collected from potential spring-run Chinook salmon holding pools within the Feather River. Water temperature, water depth and DO data were collected by SP-W6 in support of this and other water quality tasks associated with the FERC relicensing process. During the spring-run Chinook salmon holding period, water temperature, dissolved oxygen and water depth data were collected from April 30, 2002 through October 25, 2002. A portion of the data was lost during field activities... **Table 4.7-1** shows the dates and locations for which water temperature and water depth data are available. **Figure 4.7-1** through **Figure 4.7-6** show a series of maps with the locations of each sampled pool plotted on them. Generally DO data exist for all dates and locations where water temperature and water depth data exist with the exception of the May 16, 2002 sampling date. On that date, the DO meter failed to calibrate properly and therefore DO data were not taken. All other available data for the 16 pools sampled, including water temperature, water depth and DO concentration are represented in Appendix A. Biweekly data exists for the period from late April 2002 through October 2002 for the three most upstream pools sampled, all of which are located within the reach from the Thermalito Diversion Dam to the Thermalito Afterbay Outlet above Mathews Riffle. All pool locations downstream from Highway 162, including the pool labeled “Upstream from HWY 162 Bridge Pool” (Pool 1-4), contain data from August 2002 through October 25, 2002. Pools downstream from and including the pool labeled “Upstream from Yuba River Pool” (Pool 4-2) were sampled on three dates in August 2002, and on two dates in both September and October 2002. The sampled pools were selected by searching for the deepest pools at locations that were near DWR’s water quality and/or temperature recorder locations on the Feather River (pers. com., S. McReynolds, DWR, 2003). In cases where no distinct deep pools were located near water quality and/or temperature recorders, habitat types were sampled that had similar characteristics to deep pools (pers. com., S. McReynolds, DWR, 2003).

A typical sampling event during the spring and early fall months began at Verona and continued upstream to the Fish Barrier Dam on the Feather River. This stretch of river could be covered in one day during the spring and fall due to sufficient daylight into the early evening. During the time of year when days were shorter, DWR field crews usually ascended the river to the Near Mile Long Pond (Pool 3-2) or the Afterbay Pool (Pool 2-2). The remaining locations were sampled the following morning upstream from the last station monitored on the previous day. Sampling was completed using a YSI Model 550DO Dissolved Oxygen/Temperature meter with a seven-meter cable and a USGS Columbus Type Sounding Weight. The probe was attached to the approximately 15 pound sounding weight and lowered to a depth of 0.5 meters for an initial reading. The meter was calibrated at the first station sampled on each day by performing a Winkler titration for dissolved oxygen (mg/L). Once calibrated, the DO probe was brought up to approximately two inches below the water's surface. Water temperature and DO were then recorded in a write-in-the-rain notebook. Subsequent readings were recorded in 0.5 meter increments until the bottom of the pool was reached (pers. com., S. McReynolds, DWR, 2003).

Table 4.7-1. Mean water column temperature for each pool, for each sampling date, within the adult spring-run Chinook salmon holding period.

	04/30/02	05/16/02	05/30/02	06/12/02	06/27/02	07/15/02	07/25/02	08/07/02	08/22/02	08/26/02	09/05/02	09/26-27/02	10/8-9/02	10/24-25/02
Feather River downstream from Fish Barrier Dam Pool (Pool 1-1)	10.4	10.7	13.4	11.9	13.6	12.4	12.4		16.3	13.7	12.3	11.7	12.9	13.4
Feather River upstream from Hatchery Pool (Pool 1-2)	10.7	10.8	13.3	12.2	13.7	12.5	14.0		16.2	13.8	12.2	11.6	12.9	13.4
Feather River downstream from Hatchery Pool (Pool 1-3)	11.4	11.4	13.4	12.7	14.4	13.1	14.3		16.9	14.0	12.5	11.6	13.6	13.3
Feather R upstream from HWY 162 Bridge Pool (Pool 1-4)									18.0	14.9	14.0	11.6	14.7	13.3
Feather R US from Afterbay Outlet Pool (Pool 2-1)									18.4	16.2	14.8	13.3	15.0	13.8
Feather River at Afterbay Outlet Pool (Pool 2-2)									17.8	17.7	15.8	14.6	15.9	14.6
Feather R downstream from Afterbay Outlet Pool (Pool 3-1)									17.3	18.0	16.7	15.7	15.9	14.6
Feather R near Mile Long Pond Pool (Pool 3-2)									17.6	18.7	17.2	16.2	16.6	14.8
Feather R DS from Project Boundary Pool (Pool 3-3)									17.8	18.7	17.4	16.8	16.7	15.0
Feather R NR Gridley Pool (Pool 3-4)									17.7	19.0	17.1	16.7	16.5	14.8
Feather River Upstream from Honcut Creek(Pool 3-5)									17.7	19.2	16.8	16.6	16.3	14.7
Feather River at Archer Ave. Pool (Pool 4-1)									17.9	19.5	16.8	16.7	16.6	15.0
Feather River upstream from Yuba R. Pool (Pool 4-2)								20.0	18.6	20.1	17.2	17.9	17.0	14.9
Feather River at Shanghai Bend Pool (Pool 4-3)								18.7	18.5	19.4	17.4	18.0	17.0	14.8
Feather R A Star Bend Pool (Pool 4-4)								19.1	18.9	19.7	17.7	17.9	17.2	15.1
Feather R NR Verona Pool (Pool 4-5)								19.2	18.9	19.7	18.5	18.8	17.8	14.8

Water temperature (°C)	Color code
6.0 - 14.9	
15.0 - 16.9	
= 17.0	
No data	

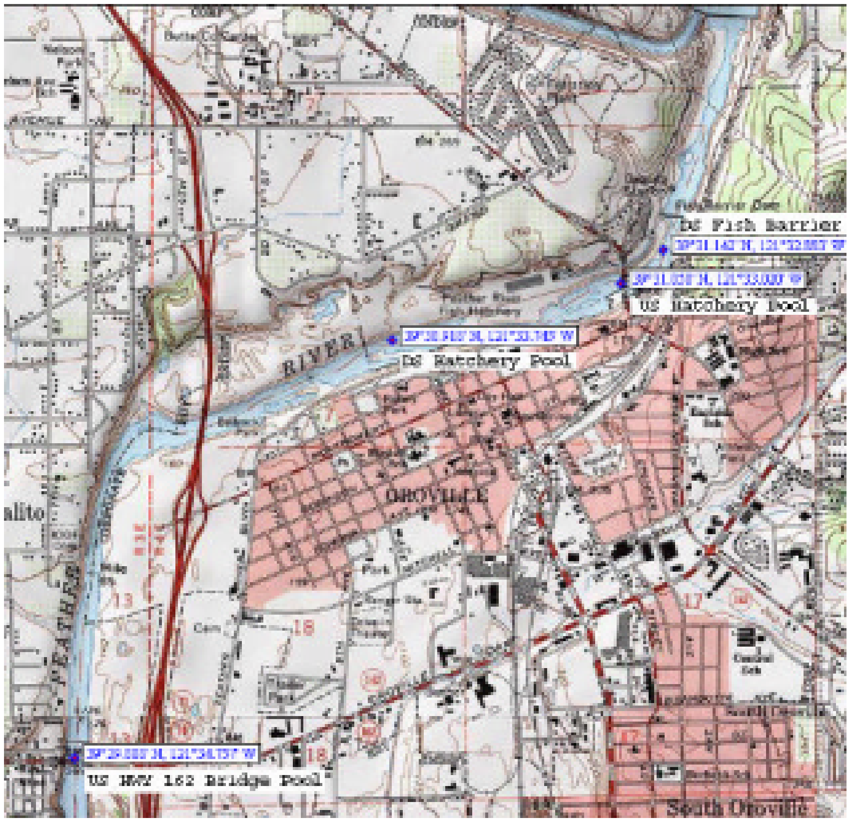

Figure 4.7-1. Sample Pool Locations in Reach 1 Between the Fish Barrier Dam and Mathews Riffle.

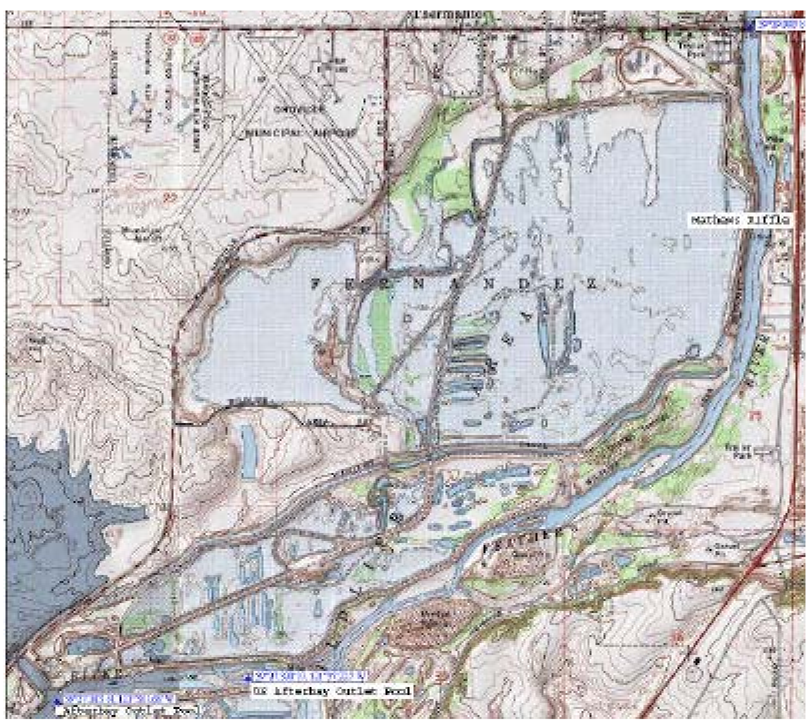

Figure 4.7-2. Sample Pool Locations in Reach 2 Between the Mathews Riffle and the Thermalito Afterbay Outlet.

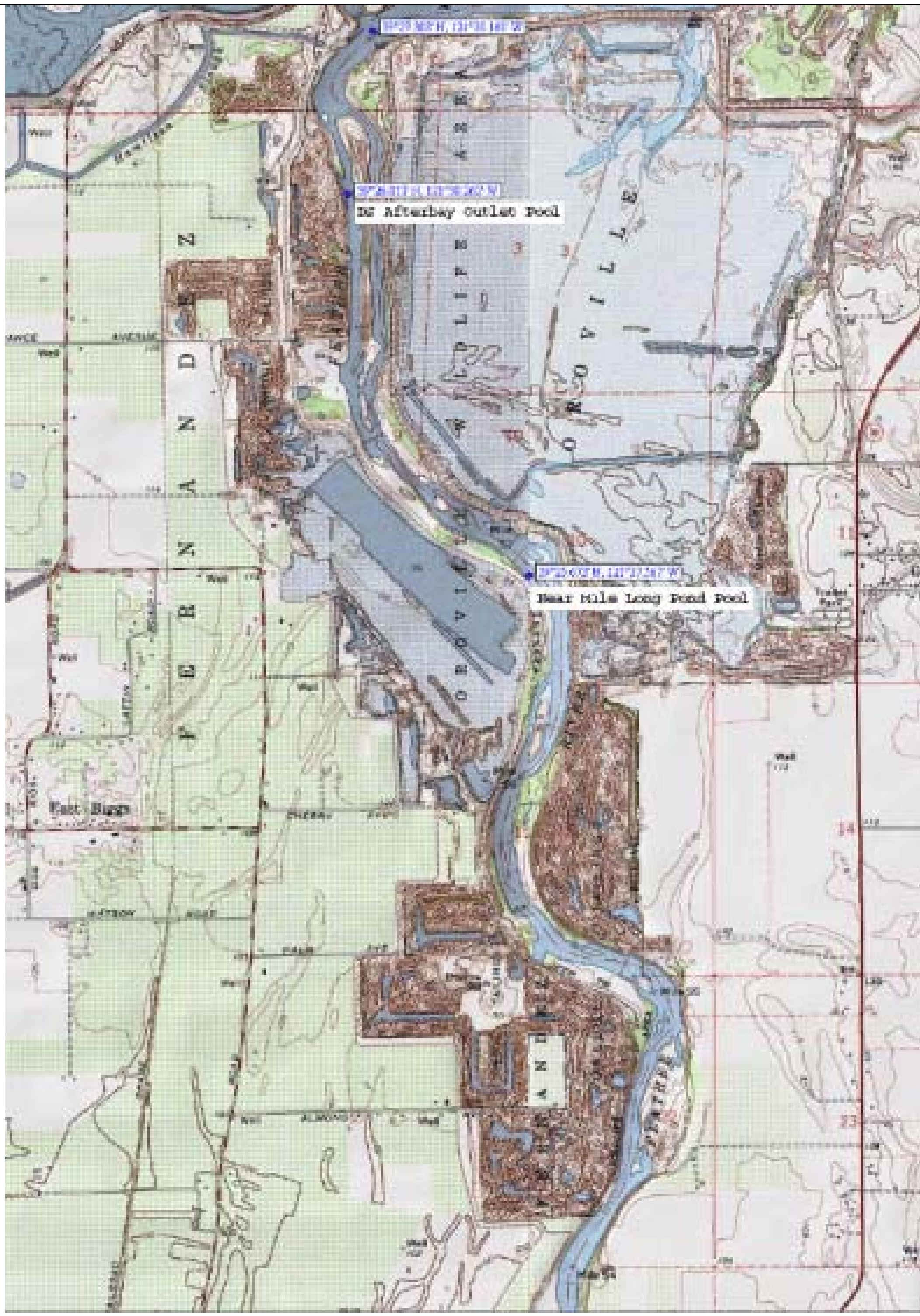

Figure 4.7-3. Sample Pool Locations in the Upper Portion of Reach 3 Between the Thermalito Afterbay Outlet and Honcut Creek.

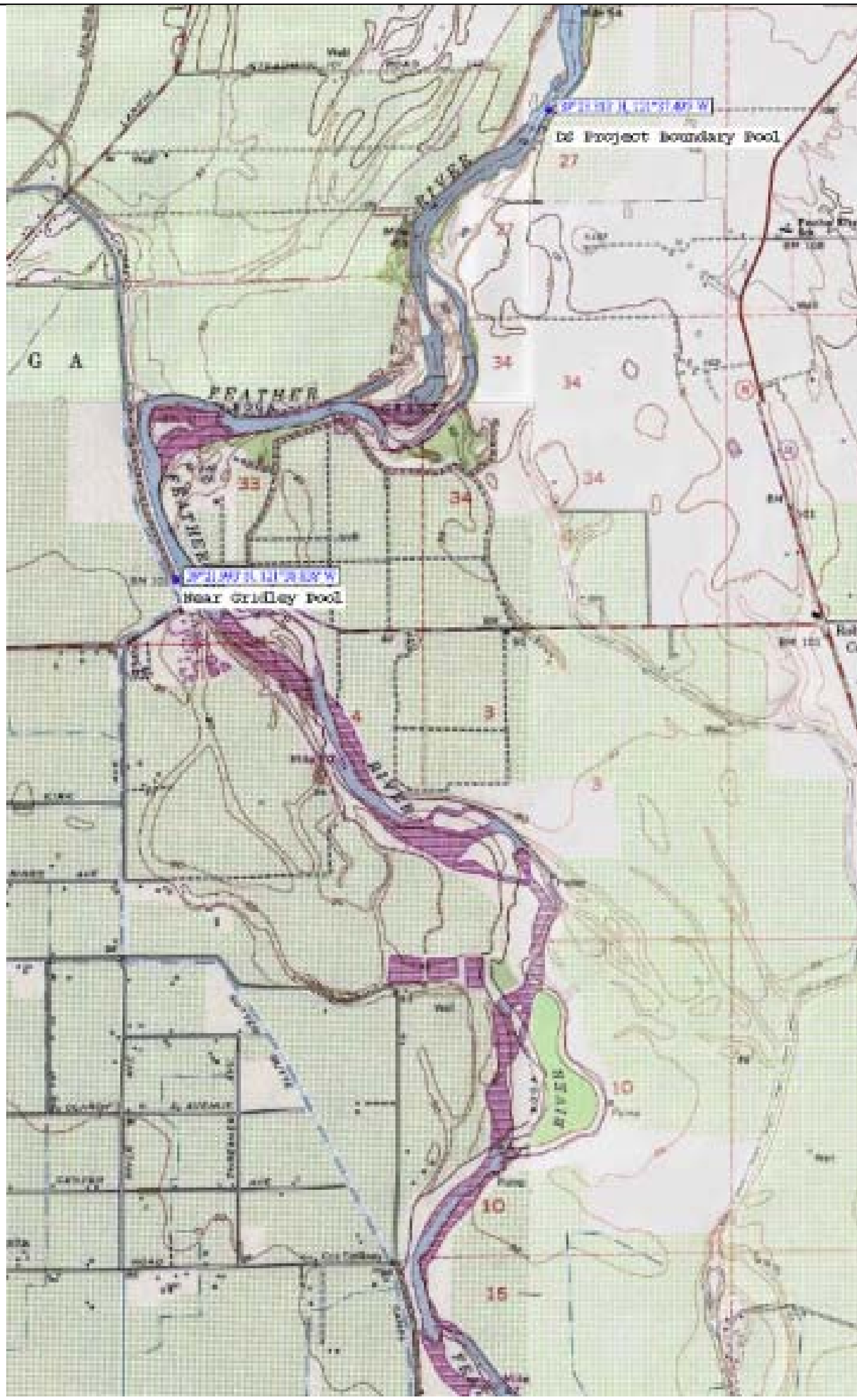

Figure 4.7-4. Sample Pool Locations in the Middle Portion of Reach 3 Between the Thermalito Afterbay Outlet and Honcut Creek.

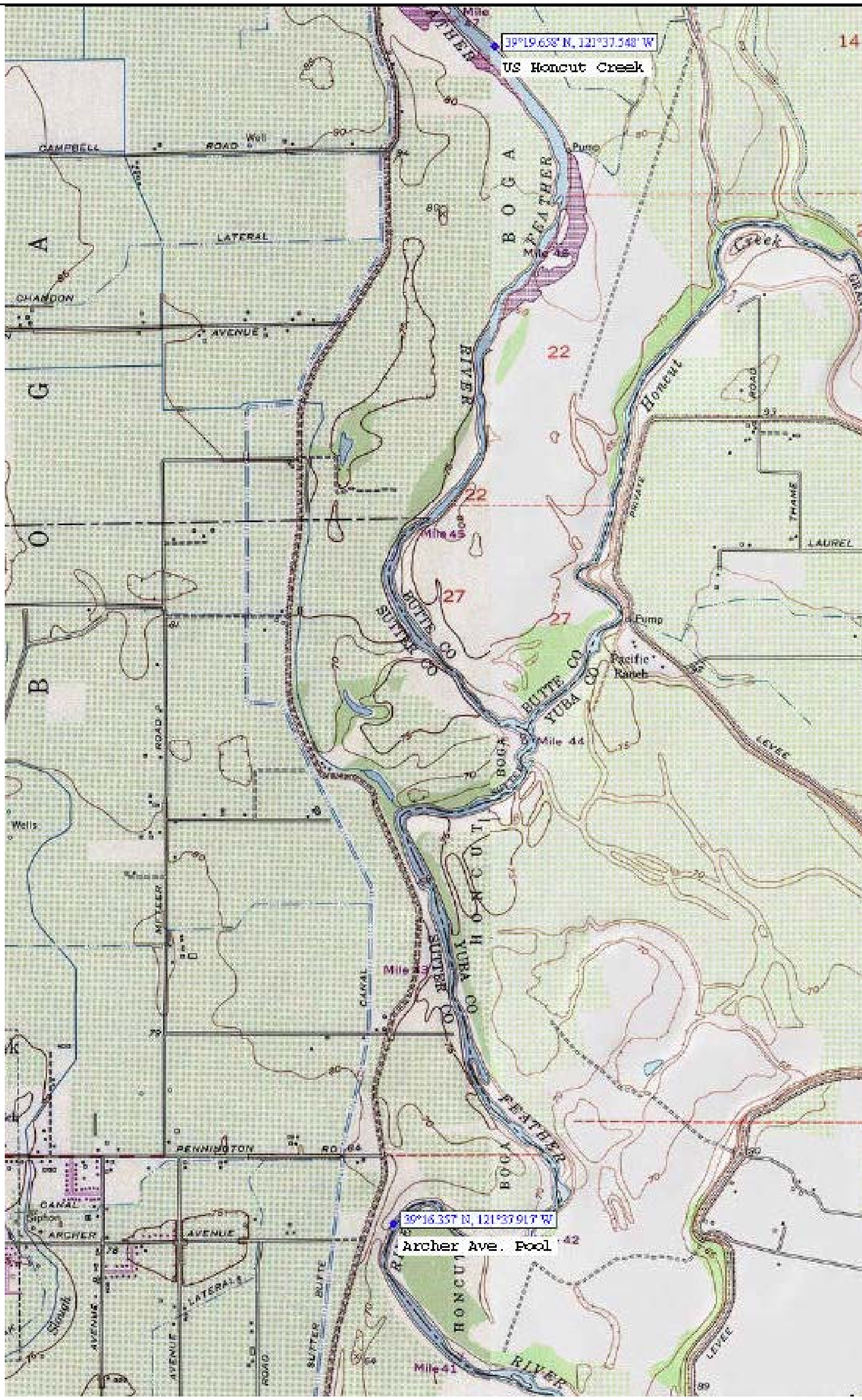

Figure 4.7-5. Sample Pool Locations in the Lower Portion of Reach 3 Between the Thermalito Afterbay Outlet and Honcut Creek and in the Upper Portion of Reach 4 Between Honcut Creek and the Sacramento River.

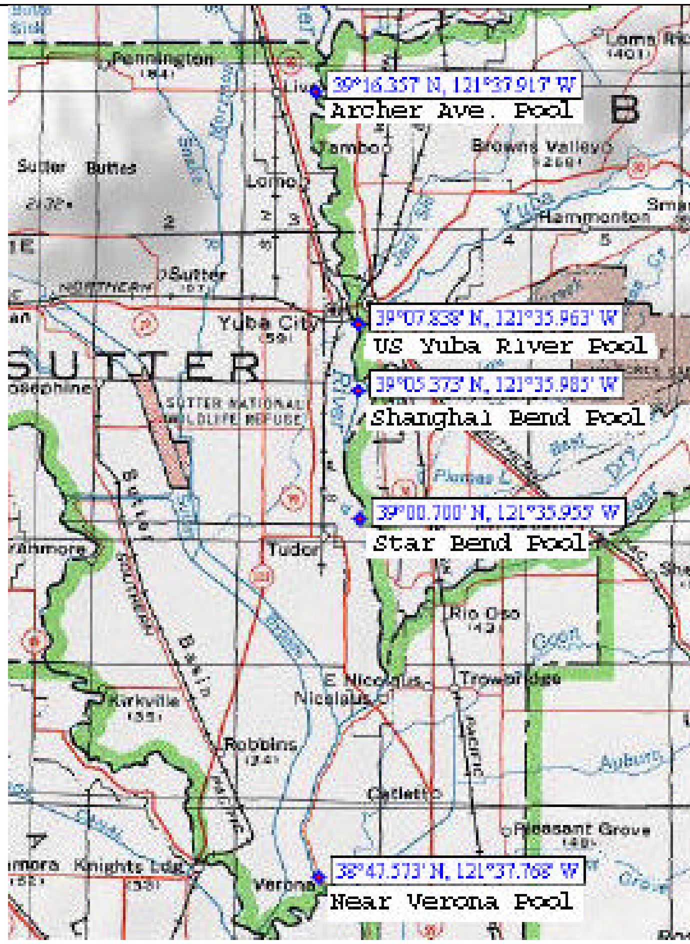

Figure 4.7-6. Sample Pool Locations in Reach 4 Between Honcut Creek and the Sacramento River.

4.8 EVALUATION OF THE ORIGINAL STUDY PLAN

Modification in data collection methodology from the original study plan was due, in part, to the limitations in the mesohabitat maps that were to be used to select sample pools. Prior to the first sampling effort, pools below Mathews Riffle were to be stratified using various criteria including size and depth and randomly based on that stratification. Mesohabitat maps produced by SP-G2 were to be used to stratify pools by size. Difficulty obtaining current mesohabitat maps along with a lack of data on depth and pool size precluded stratification prior to sampling. A mesohabitat map produced in 1999 by DWR was examined to determine the feasibility of substituting it for more current maps. It was determined, however, that it would be infeasible to use maps produced in 1999 due to the lack of information regarding pool depth and potential limitations associated with using outdated maps or maps inconsistent with other FERC relicensing plans (i.e., SP-G2). Thus, using the best available option, DWR personnel used their best professional opinion to select pools from which to collect data.

Within the reach that extends from the Fish Barrier Dam to Mathews Riffle, four pools were selected for sampling. Between Mathews Riffle and the Thermalito Afterbay Outlet, two pools were sampled. Between the Thermalito Afterbay Outlet and Honcut Creek, five pools were selected, and downstream from Honcut Creek, five pools were sampled. Substrate and cover data were not collected for any of the sixteen pools that were sampled.

A potential limitation of the original study plan design includes the temporal resolution of the water temperature data set. Collection of temperature data biweekly may not provide an accurate reflection of the overall suitability of holding habitat in the river. Biweekly data collection may not provide a representative temperature profile during times when flows are changed during the warmest months of the summer when holding occurs, and may not be representative of actual mean monthly water temperatures.

4.9 ANALYSIS OF DATA COLLECTED IN FEATHER RIVER POOLS

Analysis of the water temperature and dissolved oxygen data was performed by comparing collected data to existing information on suitable habitat for spring-run Chinook salmon holding. Once a comparison between existing information and the collected data was made, conclusions could be reached regarding the location and extent of suitable spring-run Chinook salmon holding habitat in the lower Feather River.

To analyze the water temperature data collected for the sixteen sampled pools, each sample date and location was individually assessed. At no time was data from an individual sampling date or combination of sampling dates within one month considered representative of that month. Therefore, data from individual sample dates should not be used to infer monthly water temperature trends. Each pool sampled was also considered individually. No inference was, or should be, made that any individual pool water temperature is representative of a reach, habitat type, or other pool upstream or downstream from the sampled pool.

To analyze individual pool suitability for holding adult spring-run Chinook salmon, the mean water column temperature was calculated and analyzed compared to the index water temperatures of 15º C and 17º C. These indices were used because they are the endpoint water temperatures in the range at which sublethal effects are reported to begin to occur in salmon chronically exposed to that water temperature range. If mean water temperatures in a given pool for a given date were below 15º C, then it was considered that for that sample date in that individual pool, water temperatures were suitable for holding adult Chinook salmon. If mean water temperatures in a given pool for a given date were above 17º C, then it was considered that for that sample date in that pool, that water temperatures were unsuitable for holding adult Chinook salmon. For pools with mean water temperatures between 15º C and 17º C it is unclear whether that pool on that sampling date provided suitable habitat holding adult Chinook salmon.

In addition to analysis of water temperature, water depth and DO data collected by DWR were compared to published data in order to identify and characterize potential holding habitat for spring-run Chinook salmon. The published EPA thirty-day mean DO concentration of 6.5 mg/L was used as the threshold for this analysis, while a depth of 2 meters was used as the threshold for suitable holding pool habitat.

Little data exists describing the size of preferred holding pools for adult spring-run Chinook salmon. Neither the DFG's status review of spring-run Chinook salmon in the

Sacramento River drainage or the DWR and USBR's Biological Assessment of the effects of the State Water Project and Central Valley Project on steelhead and spring-run Chinook salmon mention pool size as an important criterion in determining holding pool habitat suitability. As a result, pool size was not considered in this analysis. The habitat utilization portion of Task 1E will aid in determining if there is a correlation between pool size and pool use for holding.

Additional parameters that were not considered for this analysis of holding pool habitat in the Feather River include substrate, cover, and velocity. This data set does not exist for the pools for which other data (water temperature, DO, and water depth) do exist. It is anticipated that during the second season of sampling, these data will be collected for analysis.

5.0 RESULTS AND DISCUSSION

5.1 ANALYSIS OF DATA COLLECTED IN FEATHER RIVER POOLS

5.1.1 Water temperature

Analysis of water temperature data in potential spring-run Chinook salmon holding habitat was performed using index water temperatures based on endpoints of ranges reported by Marine (1992) that had various effects on chronically exposed adult Chinook salmon (Marine 1992). The incipient upper lethal water temperature reported by Marine (1992) fell between 17º C and 20º C. The water temperature range in which Marine (1992) reported sublethal effects occurring was between 15º C and 17º C. The range reported for optimal pre-spawning broodstock survival, maturation, and spawning was between 6º C and 14º C (Marine 1992). Because no effects were reported for chronic exposure to temperatures between 14º C and 15º C, and because the sublethal effects reportedly begin at 15º C, it was assumed that between 14º C and 15º C that no effects on holding adult Chinook salmon would occur. Below 6º C, Marine (1992) reported that increased mortality, retarded gonadal development and maturation, and infertility occurred in chronically exposed adult Chinook salmon (Marine 1992). Therefore, mean pool temperatures that fell below 6º C were considered unsuitable habitat for holding adult salmon in the Feather River. Analysis of available data shows that no sampled pools had mean water temperatures below 6º C. Because data was lost and because sampling only began in April (holding is assumed to begin in March), it is not possible to report that mean pool water temperatures did not go below 6º C at any time during the holding period in pools with suitable habitat characteristics. Although not used in this analysis, data does exist for most pools in December and all pools in January. Because mean water temperatures did not fall below 8.6º C, it is assumed that mean water temperatures will not fall below 6º C in any potentially suitable holding pools during the holding period.

Most pools sampled show mean water temperatures within the range reported by Marine (1992) as optimal for pre-spawning broodstock survival and maturation on some sample dates during the holding period. Most pools have mean water column temperatures that fall between 15º C and 17º C on some sampling dates within the holding period, and mean water column temperatures that fall above 17º C on some sampling dates within the holding period. Table 4.7-1 shows all available mean water temperatures for all sampled pools within the holding period. Appendix A shows all raw temperature data collected by DWR from April 2002 through January 2003, while Appendix B contains graphs showing the dates for which each pool was above 17º C, between 15º C and 17º C, and below 15º C.

5.1.1.1 Reach 1

Between the Fish Barrier Dam and Mathews Riffle (Reach 1), mean water column temperatures are within the reported optimal range for most of the sampling dates for which data is available (Table 4.7-1). Pools 1-1, 1-2, and 1-3 have mean water temperatures between 6º C and 14º C on 12 out of 13 sampling dates within the holding period. Mean water temperatures for the sample date August 22, 2002 fell between 15º

C and 17º C. Data for the sample date August 7, 2002 was lost while no data was collected prior to April 30, 2002. In Pool 1-4, data only exists from August 22, 2002 through the end of the holding period representing six sampling dates. On all but one of those dates, mean water temperatures were in the 6º C to 15º C range. The mean water temperature on August 22, 2002 was above 17º C. Within this reach, suitable water temperatures existed on most sampling dates, but on one date (August 22, 2002) in the three most upstream pools, mean water temperatures were within the range likely to produce sublethal effects on holding salmon. In the most downstream pool within this reach (Pool 1-4) mean water temperature on August 22, 2002 fell within incipient lethal (Table 4.7-1).

5.1.1.2 Reach 2

Between Mathews Riffle and the Thermalito Afterbay Outlet (Reach 2), both of the sampled pools had six dates worth of data beginning on August 22, 2002 and continuing through October 24, 2002. Data collected prior to August 22, 2002 was lost. Pool 2-1 had mean water column temperatures within the reported optimal range on three of the six dates, between 15º C and 17º C on two dates, and above 17º C on August 22, 2002. Pool 2-2 had mean water column temperatures within the reported optimal range on two of the six dates, between 15º C and 17º C on two dates, and above 17º C on two dates. Within this reach, suitable holding habitat existed on some dates during the holding period, but on some dates during the warmest summer month (August) pool water temperatures were within the potentially sublethal and incipient lethal range for chronically exposed Chinook salmon (Table 4.7-1).

5.1.1.3 Reach 3

Between the Thermalito Afterbay Outlet and Honcut Creek (Reach 3), data exists for all five pools sampled from August 22, 2002 through October 24, 2002, representing six sample dates. On only one date (October 24, 2002) did water temperatures in four pools (Pools 3-1, 3-2, 3-4, 3-5) fall within the reported optimal range for holding. Mean water temperatures within the fifth pool (Pool 3-3) were never within the reported optimal range on any sample dates within the holding period. On August 22, and 26, 2002 all of the pools had mean water temperatures above 17º C. On September 5, 2002, Pools 3-1 and 3-5 had water temperatures between 15º C and 17º C, while Pools 3-2, 3-3, and 3-4 had mean water temperatures above 17º C. Within this reach, suitable water temperatures for holding occurred in some of the pools on October 24, 2002, near the end of the holding period. All of the pools within the reach exhibited mean water temperatures within the sublethal and incipient lethal ranges on most sampled dates within the holding period (Table 4.7-1).

5.1.1.4 Reach 4

Between the confluence of the Feather River and Honcut Creek, and the confluence of the Sacramento and Feather rivers (Reach 4), data exists for seven dates between August 7, 2002 and October 24, 2002. An exception is that data for the most upstream pool in the reach (Pool 4-1) was lost for the August 7 sampling date. Mean water column temperatures in only three pools (Pool 4-2, 4-3, and 4-5) were within the reported optimal range for holding salmon on the last sampled date within the holding period (October 24). The remaining two pools had mean water temperatures between 15º C and 17º C on that date. Only one pool, Pool 4-1, had mean water temperatures between 15º C and 17º C on four sampling dates (September 9 and 26, and October 8 and 24). For all dates and all pools within this reach, mean water column temperatures were above 17º C except for the specific instances reported above. Therefore, within reach four (Honcut Creek to the Sacramento River), suitable water column temperatures were recorded only in three pools on the last sampling date within the holding period. Sublethal mean water column temperatures were recorded on four dates within the most upstream pool, while the remainder of the dates sampled had mean water temperatures within each pool that are likely within the upper incipient lethal range reported for chronically exposed salmon (> 17º C). Table 4.7-1 shows mean water temperatures in sampled pools in the Feather River reach that extends from the confluence of Honcut Creek and the Feather River to the confluence of the Sacramento and Feather rivers.

5.1.1.5 August Water Temperatures

Sample dates in August yielded the warmest water temperatures for all sample locations and all sample dates. **Figure 5.1-1** shows the average mean water column temperatures for all available data for the month of August for each sampled pool. These values were calculated by averaging mean water column temperatures from each pool for each sample date in August. For example, the mean water column temperatures presented in Table 4.7-1 for Pool 4-5 (the most downstream pool sampled) for August 7, 22, and 26 were 19.2º C, 18.9º C, and 19.7º C, respectively. The mean of these three water temperatures (19.3º C) is presented in Figure 5.1-1. The error bars shown on the figure indicate the minimum and maximum mean water column temperatures reported for any of those sample dates.

5.1.1.6 Temperature and Flow Fluctuations

Potentially significant differences in water temperatures between sampling dates in August occur throughout the study area. In the two reaches above the Thermalito Afterbay Outlet, mean water column temperatures in sampled pools decreased an average of approximately 2.2º C between August 22 and August 26, 2002 while the two reaches below the Thermalito Afterbay Outlet showed an average increase of approximately 1.1 º C in mean water column temperature for the same dates. The temperature changes can be attributed to increases in flow releases from Oroville Dam and the Thermalito Afterbay. Calibration of the Instream Flow Incremental Methodology (IFIM) model developed for other tasks associated with the FERC relicensing process required increased flows in the river.

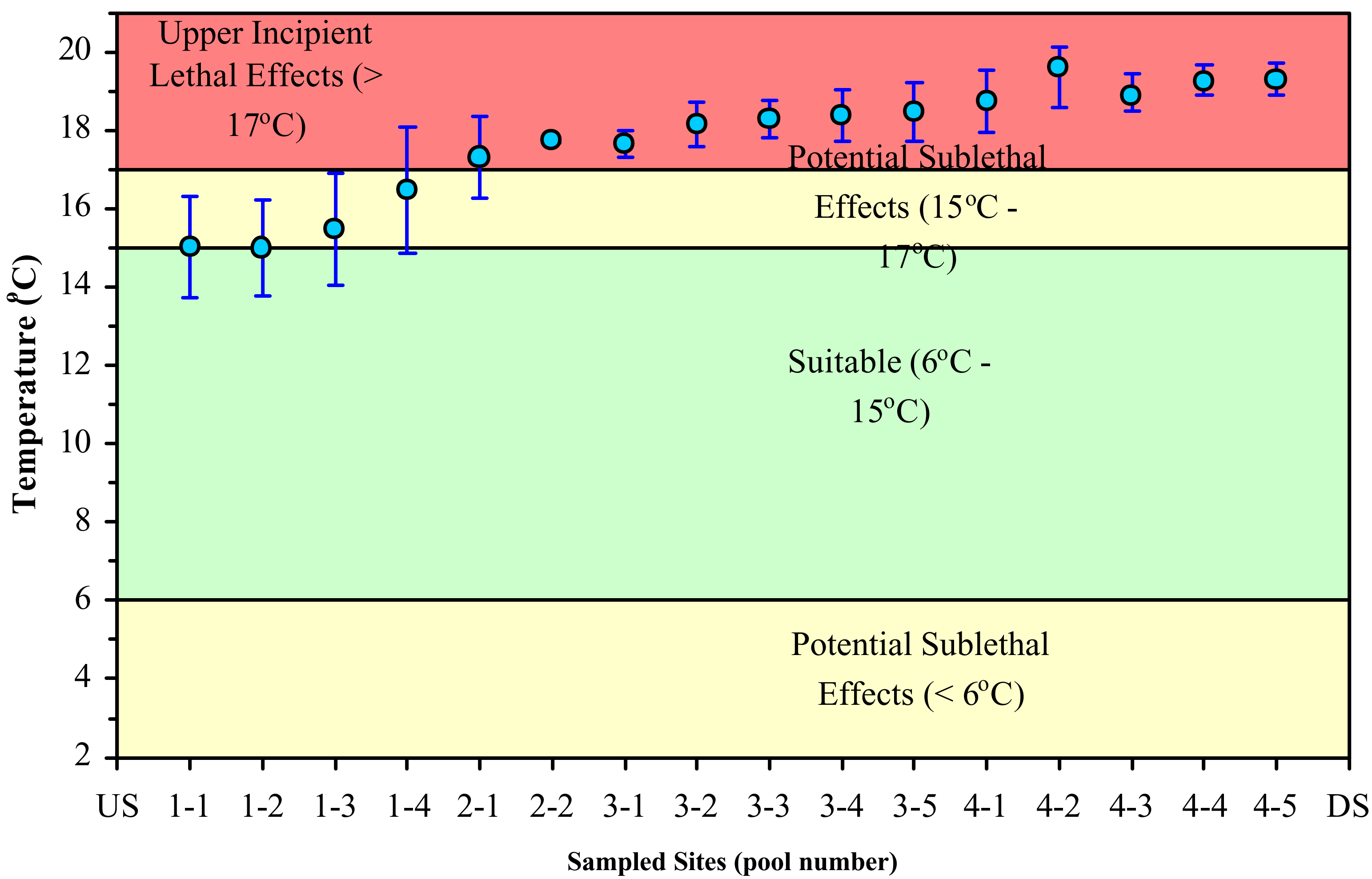

Figure 5.1-1. Average mean water column temperatures for August sampling dates for each Feather River sample site, from upstream (US) to downstream (DS). Error bars indicate the minimum and maximum mean water column temperatures.

Because water drawn from the hypolimnion Lake Oroville and released into the reach above the Thermalito Afterbay Outlet was cold, water temperatures in that reach decreased with higher flows. The opposite effect is evident below the Thermalito Afterbay Outlet because water entering the Feather River from the Thermalito Afterbay is warmer than the river itself. In order to fully identify and characterize suitable holding habitat within the Feather River, a larger data set is required.

5.1.2 Dissolved Oxygen

Based on the dissolved oxygen concentrations reported by the EPA to be sufficient to support coldwater aquatic species, all pools sampled on all dates can be considered suitable habitat for holding adult spring-run Chinook salmon. **Appendix A** shows the raw data collected by DWR for all pools sampled. The thirty-day mean DO value reported to be suitable for all lifestages other than embryonic, larval, or juvenile organisms is reported to be 6.5 mg/L. The thirty-day mean value was used because it is the most conservative value provided for post-juvenile lifestages. At no time during sampling was DO less than 6.5 mg/L. In fact, the lowest DO concentration reported during the holding period was 8.5 mg/L, recorded on August 26, 2002 at the Shanghai Bend Pool (Pool 4-3).

5.1.2.1 Dissolved Oxygen and Flow Fluctuations

In addition to changes in mean water column temperatures observed between sampling dates in August 2002, changes in DO concentration also were observed. In general, DO concentrations increased at sample locations in Reaches 1 and 2 (upstream of the Thermalito Afterbay Outlet) and decreased at sample locations in Reaches 3 and 4 between August 22 and August 26 2002. These changes are presumably due to the increased flow releases during calibration of the IFIM model on August 26. Because DO concentrations were not at or near the EPA minimum standard at any locations during the holding period, it is not anticipated that changes in flows similar to those during the IFIM calibration would decrease habitat suitability based on DO concentration.

5.1.3 Diel Temperature and Dissolved Oxygen Fluctuations

Evidence from the Middle Fork Eel River shows that under certain flow conditions potentially significant changes in water temperatures can occur in a single pool during a single day (Nielsen et al. 1994). In fact, Nielsen and others (1994) suggest that surface water temperatures increased consistently by 3.5º C during the day under low flow conditions. It is unclear whether this pattern would be evident under flow conditions exhibited in the Feather River. A cursory examination of available data in Pool 1-1 (the most upstream pool sampled –Figure 4.7-1, Table 4.7-1) shows that between sample date July 25, 2002 and August 22, 2002 mean water column temperatures increased from 12.4º C to 16.3º C. A difference in sampling time from 0755 on July 25 to 1555 on August 22 is one factor among several that could cause a 3.9º C increase in mean water column temperature between sampling dates. However, samples taken in the same pool (Pool 1-1) at similar times on August 22 and September 5 show a mean water temperature difference of 4º C. This indicates that the time of year during which a sample was taken has a stronger influence on water temperature than the time of day, but does not provide evidence that sampling time does not affect mean water column temperature. It is suggested that water temperatures be taken at several times during the day in individual pools to determine to what extent mean water column temperature is diurnally influenced.

Evidence exists to suggest that DO concentration exhibits the opposite reaction to the diel cycle than water temperature. It has been reported in some systems, due to photosynthesis, heavy plant growth during the summer months can lead to oxygen supersaturation during the day (Giller et al. 2002). Because no DO concentrations are at or near the EPA minimum standard for coldwater species during the holding period, it is not expected that DO concentration is a limiting factor in holding habitat availability in the Feather River. Without DO concentration measurements in individual pools at multiple times during any given day, it is not possible to rule out a drop in DO concentration below the EPA minimum at times during the holding period. It is suggested that DO concentration measurements be taken at several times at night as well as during the day in several individual pools to examine whether DO concentrations are suitable throughout the diel cycle.

5.1.4 Water Depth, Substrate, Cover, and Water Velocity

Based on available information on adult spring-run Chinook salmon holding habitat with respect to water depth, all pools sampled provided suitable habitat at all dates sampled within the holding period, with few exceptions. Pools 1-3, 3-2, 4-2, and 4-5 were 1.5 meters deep on some of the sampling dates. Since pool depth is related to flow, the depth of these pools was suitable for some dates during the holding period. Other parameters that could potentially determine the presence, location, and distribution of suitable holding habitat include substrate, cover, and velocity. None of these parameters were analyzed because no data was collected from the sampled pools during the holding period. It is expected that substrate, cover, and velocity data will be available for analysis for the final report for Task 1E.

5.1.4.1 Pool Depth Measurements

On August 26, 2002 flows were higher than on other sampling dates due to an effort to calibrate the IFIM model. Above the Thermalito Afterbay Outlet, the depth in all pools remained the same or increased. Some pools below the Thermalito Afterbay Outlet, however, showed decreases in depth during the IFIM Calibration on August 26. Pools 3-1 and 4-2 decreased in depth by approximately half a meter each during the IFIM calibration. Pools 4-1 and 4-4 each got shallower by a full meter during the increased flows on August 26. Additionally, all four of the other pools within Reach 3 remained at the same depth. Pool 4-3 increased in depth by a half meter and Pool 4-5 remained at the same depth. It is possible that water depth was not measured at the exact same locations as previous measurements within each pool.

5.2 SAMPLING RECOMMENDATIONS

Although it is difficult to draw conclusions about the suitability of spring-run Chinook salmon holding habitat from the limited data available, implementation of the following recommendations should answer questions regarding the presence, distribution, and abundance of suitable holding habitat within the Feather River below Oroville Dam.

- Sampling should occur during the entire potential spring-run Chinook salmon holding period beginning in March and continuing through October.
- Sampling should occur weekly rather than biweekly.
- Pools below Mathews Riffle (RM 64) should be stratified according to the original study plan and sampled according to the protocol approved by DWR.
  - All pools between the Thermalito Diversion Dam (RM 67) and Mathews Riffle (RM 64) should be sampled.
  - Between Mathews Riffle (RM 64) and the Thermalito Afterbay Outlet (RM 59), fifty percent of the pools in each stratum should be randomly sampled.
  - Between the Thermalito Afterbay Outlet and Honcut Creek, twenty-five percent of the pools in each stratum should be randomly sampled.
- A test should be performed to determine the effects of sampling time during the day on water temperatures, and if it is shown that water temperatures are close to the ranges in which effects occur to chronically exposed fish, sampling should be done during the hottest part of the day in areas that are likely on the geographical edge of pools with suitable temperature ranges.
- A similar test should be performed for DO concentration.
- Substrate and cover data should be collected for each pool sampled.
- Water velocity data should be collected for each pool sampled.
  - Water velocities across a representative transect should be taken at half meter depth intervals. Mean water column velocities will then be used to determine the presence of suitable water velocities in potential holding pools.

6.0 CONCLUSIONS

Limited preliminary conclusions about the availability of suitable holding habitat can be drawn for some parameters. For other parameters, the limited amount of data available, combined with the uncertainty about the whether sample dates and locations are representative of available habitat, lead to the conclusion that a larger data set is needed to determine the presence, location and distribution of suitable holding habitat. Preliminary results suggest all sample sites have mean water temperatures within the reported optimum range for pre-spawning broodstock survival, maturation and spawning on some dates during the holding period. However, most sample sites have mean water temperatures within the reported range where sublethal effects may occur in chronically exposed broodstock on some dates during the holding period. Additionally, most sample sites downstream of Mathews Riffle have mean water column temperatures within the reported upper incipient lethal temperature range on some dates during the holding period. Only one pool upstream of Mathews Riffle exhibited water temperatures within this range on one sampling date. At all sample sites on all dates, dissolved oxygen concentrations are above recommended EPA minimums for coldwater species. Additionally, all sample sites are equal to or deeper than two meters with the exception of four pools (1-3, 3-2, 4-2, and 4-5).

Conclusions regarding water temperature suitability for adult holding spring-run Chinook salmon cannot be drawn without a complete set of water temperature data taken throughout the entire holding period. It is expected that these data will be available after the 2003 sampling season. Pools of suitable depth are available during the holding period; however, not all pools sampled were of suitable depth throughout the holding period. In addition to a complete set of temperature data, it is expected that the description of adult Chinook salmon holding habitat use and subsequent spawning status will be completed for upmigration and spawning periods and will be integrated into this report.

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OROVILLE FERC RELICENSING
(PROJECT NO. 2100)

INTERIM REPORT
SP-F10, Task 1E

APPENDIX A
WATER TEMPERATURE, DISSOLVED OXYGEN, AND DEPTH DATA COLLECTED IN FEATHER RIVER POOLS (APRIL 2002 THROUGH OCTOBER 2002)

APRIL 2003

Pool 1-1
Downstream from Fish Barrier Dam

April

Date: 4/30/2002 **Time:** 1200 P.S.T.		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**
0.0	10.4	11.6
0.5	10.4	11.7
1.0	10.4	11.7
1.5	10.4	11.7
2.0	10.4	11.7
2.5	10.4	11.7
3.0	10.4	11.7
3.5	10.4	11.7
4.0	10.4	11.7
Mean	10.4	11.7

May

Date: 5/16/2002 **Time:** 0740 P.S.T.			**Date:** 5/30/2002 **Time:** N/A		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	10.8	N/A	0.0	13.4	10.4
0.5	10.8	11.0 (W)	0.5	13.4	10.5 (W)
1.0	10.7	N/A	1.0	13.4	10.3
1.5	10.7	N/A	1.5	13.4	10.3
2.0	10.7	N/A	2.0	13.4	10.3
2.5	10.7	N/A	2.5	13.4	10.3
3.0	10.7	N/A	3.0	13.4	10.3
3.5	10.7	N/A	3.5	13.4	10.2
Mean	10.7	N/A	Mean	13.4	10.3

June

Date: 6/12/2002 **Time:** 0915 PST			**Date:** 6/27/2002 **Time:** 0830 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	12.0	10.4	0.0	13.6	10.2
0.5	12.0	10.4	0.5	13.6	10.2
1.0	12.0	10.4	1.0	13.6	10.2
1.5	12.0	10.4	1.5	13.6	10.2
2.0	12.0	10.4	2.0	13.6	10.2
2.5	11.9	10.4	2.5	13.6	10.2
3.0	11.9	10.4	3.0	13.6	10.2
3.5	11.9	10.4	3.5	13.6	10.2
4.0	11.9	10.4	4.0	13.6	10.2
4.5	11.9	10.4	4.5	13.6	10.1
5.0	11.9	10.4	5.0	13.6	10.1
5.5	11.9	10.4			
6.0	11.9	10.4			
Mean	11.9	10.4	Mean	13.6	10.2

July

Date: 7/15/2002 **Time:** 0830 PST			**Date:** 7/25/2002 **Time:** 0755 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	12.4	9.6	0.0	12.4	9.6
0.5	12.4	9.6	0.5	12.4	9.6
1.0	12.4	9.7	1.0	12.4	9.7
1.5	12.4	9.6	1.5	12.4	9.6
2.0	12.4	9.6	2.0	12.4	9.6
2.5	12.4	9.5	2.5	12.4	9.5
3.0	12.4	9.5	3.0	12.4	9.5
3.5	12.4	9.5	3.5	12.4	9.5
4.0	12.4	9.5	4.0	12.4	9.5
4.5	12.4	9.4	4.5	12.4	9.4
5.0	12.4	9.4	5.0	12.4	9.4
5.5	12.4	9.4	5.5	12.4	9.4
6.0	12.4	9.3	6.0	12.4	9.3
6.5	12.4	9.3			
7.0	12.4	9.4			
Mean	12.4	9.5	Mean	12.4	9.5

August

Date: 8/22/2002 **Time:** 1555 PST			**Date:** 8/26/2002 **Time:** 1530 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.4	9.1	0.0	13.8	10.4
0.5	16.4	9.2	0.5	13.8	10.4
1.0	16.4	9.2	1.0	13.7	10.4
1.5	16.3	9.2	1.5	13.7	10.4
2.0	16.3	9.2	2.0	13.7	10.3
2.5	16.3	9.2	2.5	13.7	10.4
3.0	16.3	9.2	3.0	13.7	10.4
3.5	16.3	9.2	3.5	13.7	10.4
4.0	16.3	9.2	4.0	13.7	10.4
4.5	16.2	9.2	4.5	13.7	10.3
5.0	16.3	9.2	5.0	13.7	10.4
5.5	16.3	9.2	5.5	13.7	10.4
6.0	16.3	9.2	6.0	13.7	10.4
6.5	16.2	9.2	6.5	13.7	10.3
7.0	16.2	9.2	7.0	13.7	10.3
			7.5	13.7	10.3
Mean	16.3	9.2	Mean	13.7	10.4

September

Date: 9/5/2002 **Time:** 1605 PST			**Date:** 9/27/2002 **Time:** 0855 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	12.4	10.8	0.0	11.7	10.1
0.5	12.4	10.9	0.5	11.7	10.2
1.0	12.4	10.9	1.0	11.7	10.3
1.5	12.4	10.9	1.5	11.7	10.3
2.0	12.3	11.0	2.0	11.7	10.3
2.5	12.3	11.0	2.5	11.7	10.2
3.0	12.3	11.0	3.0	11.7	10.2
3.5	12.3	11.0	3.5	11.7	10.2
4.0	12.3	10.9	4.0	11.7	10.1
4.5	12.3	10.9	4.5	11.7	10.1
5.0	12.2	10.8	5.0	11.6	10.2
5.5	12.2	10.9	5.5	11.6	10.2
6.0	12.2	10.8	6.0	11.6	10.1
6.5	12.1	10.8	6.5	11.6	10.1
7.0	12.1	10.8			
Mean	12.3	10.9	Mean	11.7	10.2

October

Date: 10/9/2002 **Time:** 0830 PST			**Date:** 10/25/2002 **Time:** 0915 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	13.0	10.1	0.0	13.5	9.9
0.5	12.9	10.0	0.5	13.4	9.8
1.0	12.9	10.1	1.0	13.4	9.8
1.5	12.9	10.1	1.5	13.4	9.8
2.0	12.9	10.1	2.0	13.4	9.8
2.5	12.9	10.1	2.5	13.4	9.9
3.0	12.9	10.1	3.0	13.4	9.8
3.5	12.9	10.1	3.5	13.4	9.7
4.0	12.9	10.2	4.0	13.4	9.7
4.5	12.9	10.1	4.5	13.4	9.7
5.0	12.9	10.1	5.0	13.4	9.6
5.5	12.9	10.0	5.5	13.4	9.6
6.0	12.9	10.0	6.0	13.4	9.7
6.5	12.9	9.8	6.5	13.4	9.7
			7.0	13.4	9.5
Mean	12.9	10.1	Mean	13.4	9.7

Pool 1-2
Upstream from Hatchery Pool

April

Date: 4/30/2002 **Time:** 1230 P.S.T.		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**
0.0	11.2	11.5
0.5	11.0	11.5
1.0	10.9	11.4
1.5	10.7	11.5
2.0	10.7	11.7
2.5	10.6	11.8
3.0	10.6	11.8
3.5	10.6	11.8
4.0	10.6	11.7
4.5	10.5	11.6
5.0	10.5	11.7
Mean	10.7	11.6

May

Date: 5/16/2002 **Time:** 0800 PST			**Date:** 5/30/2002 **Time:** N/A		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	10.8	N/A	0.0	13.4	10.3
0.5	10.8	11.0 (W)	0.5	13.3	10.3 (w)
1.0	10.8	N/A	1.0	13.3	10.3
1.5	10.8	N/A	1.5	13.4	10.3
2.0	10.8	N/A	2.0	13.4	10.3
2.5	10.8	N/A	2.5	13.3	10.3
3.0	10.8	N/A	3.0	13.3	10.3
3.5	10.8	N/A	3.5	13.3	10.3
4.0	10.8	N/A	4.0	13.3	10.2
4.5	10.8	N/A			
5.0	10.8	N/A			
Mean	10.8	N/A	Mean	13.3	10.3

June

Date: 6/12/2002 **Time:** 0930 PST			**Date:** 6/27/2002 **Time:** 0850 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	12.5	10.4	0.0	13.8	10.0
0.5	12.3	10.4	0.5	13.8	10.1
1.0	12.2	10.3	1.0	13.8	10.1
1.5	12.2	10.3	1.5	13.7	10.0
2.0	12.1	10.0	2.0	13.7	10.1
2.5	12.1	10.1	2.5	13.7	10.1
3.0	12.1	10.1	3.0	13.7	10.2
3.5	12.1	10.3	3.5	13.7	10.2
4.0	12.1	10.3	4.0	13.7	10.2
4.5	12.1	10.3	4.5	13.7	10.2
5.0	12.0	10.3	5.0	13.6	10.1
			5.5	13.6	10.2
			6.0	13.6	10.1
			6.5	13.6	10.1
Mean	12.2	10.3	Mean	13.7	10.1

July

Date: 7/15/2002 **Time:** 0840 PST			**Date:** 7/25/2002 **Time:** 0805 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	12.7	9.4	0.0	14.0	9.9
0.5	12.6	9.4	0.5	14.0	10.0
1.0	12.6	9.3	1.0	14.0	10.0
1.5	12.5	9.4	1.5	14.0	10.0
2.0	12.5	9.4	2.0	14.0	10.0
2.5	12.5	9.4	2.5	14.0	10.0
3.0	12.5	9.4	3.0	14.0	10.0
3.5	12.5	9.5	3.5	14.0	10.0
4.0	12.5	9.5	4.0	14.0	9.9
4.5	12.5	9.5	4.5	14.0	9.9
5.0	12.5	9.4	5.0	14.0	9.9
5.5	12.5	9.4	5.5	13.9	9.9
6.0	12.5	9.4	6.0	13.9	9.9
6.5	12.4	9.4	6.5	13.9	9.9
Mean	12.5	9.4	Mean	14.0	10.0

August

Date: 8/22/2002 **Time:** 1540 PST			**Date:** 8/26/2002 **Time:** 1510 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.4	9.3	0.0	14.0	10.4
0.5	16.4	9.3	0.5	13.9	10.5
1.0	16.4	9.3	1.0	13.9	10.5
1.5	16.3	9.3	1.5	13.8	10.5
2.0	16.2	9.3	2.0	13.8	10.5
2.5	16.2	9.3	2.5	13.8	10.5
3.0	16.2	9.2	3.0	13.7	10.5
3.5	16.2	9.1	3.5	13.7	10.5
4.0	16.1	9.2	4.0	13.7	10.4
4.5	16.2	9.3	4.5	13.7	10.4
5.0	16.2	9.2	5.0	13.7	10.4
5.5	16.1	9.2	5.5	13.7	10.4
6.0	16.1	9.1	6.0	13.7	10.4
6.5	16.1	9.1	6.5	13.7	10.5
Mean	16.2	9.2	Mean	13.8	10.5

September

Date: 9/5/2002 **Time:** 1550 PST			**Date:** 9/27/2002 **Time:** 0845 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	12.4	10.8	0.0	11.7	10.4
0.5	12.4	10.9	0.5	11.7	10.4
1.0	12.4	10.9	1.0	11.7	10.2
1.5	12.4	10.9	1.5	11.7	10.3
2.0	12.3	10.8	2.0	11.7	10.3
2.5	12.3	10.8	2.5	11.7	10.3
3.0	12.2	10.9	3.0	11.6	10.3
3.5	12.3	10.8	3.5	11.6	10.3
4.0	12.2	10.8	4.0	11.6	10.3
4.5	12.2	10.9	4.5	11.6	10.3
5.0	12.1	10.8	5.0	11.6	10.3
5.5	12.1	10.7	5.5	11.6	10.3
6.0	12.1	10.8	6.0	11.6	10.2
6.5	12.1	10.6	6.5	11.6	10.2
Mean	12.3	10.8	Mean	11.6	10.3

October

Date: 10/9/2002 **Time:** 0850 PST			**Date:** 10/25/2002 **Time:** 0925 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	13.0	10.0	0.0	13.5	9.8
0.5	13.0	10.0	0.5	13.5	9.9
1.0	13.0	10.0	1.0	13.5	9.9
1.5	12.9	10.0	1.5	13.4	10.0
2.0	12.9	9.9	2.0	13.4	9.9
2.5	12.9	10.0	2.5	13.4	10.0
3.0	12.9	10.1	3.0	13.4	9.9
3.5	12.9	10.1	3.5	13.4	9.8
4.0	12.9	10.1	4.0	13.4	9.8
4.5	12.9	10.1	4.5	13.4	9.7
5.0	12.9	10.0	5.0	13.4	9.8
5.5	12.9	10.2	5.5	13.4	9.9
6.0	12.9	10.0	6.0	13.4	9.9
6.5	12.9	10.0	6.5	13.4	9.9
			7.0	13.4	9.9
Mean	12.9	10.0	Mean	13.4	9.9

Pool 1-3
Downstream from Hatchery

April

Date: 4/30/2002 **Time:** 1250 P.S.T.		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**
0.0	11.5	12
0.5	11.4	12
1.0	11.4	12
1.5	11.4	12
Mean	11.4	12.0

May

Date: 5/16/2002 **Time:** 0840 PST			**Date:** 5/30/2002 **Time:** 1340 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	11.5	N/A	0.0	13.4	11.1
0.5	11.4	N/A	0.5	13.4	11.1
1.0	11.4	N/A	1.0	13.4	11.1
1.5	11.4	N/A			
Mean	11.4	N/A	Mean	13.4	11.1

June

Date: 6/12/2002 **Time:** 1005 PST			**Date:** 6/27/2002 **Time:** 1000 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	12.8	11.3	0.0	14.5	11.1
0.5	12.7	11.3	0.5	14.4	11.1
1.0	12.7	11.3	1.0	14.4	11.1
1.5	12.7	11.3	1.5	14.4	11.1
Mean	12.7	11.3	Mean	14.4	11.1

July

Date: 7/15/2002 **Time:** 0920 PST			**Date:** 7/25/2002 **Time:** 0830 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	13.1	10.2	0.0	14.3	10.6
0.5	13.1	10.2	0.5	14.3	10.6
1.0	13.0	10.3	1.0	14.3	10.6
1.5	13.0	10.2	1.5	14.3	10.6
			2.0	14.3	10.5
Mean	13.1	10.2	Mean	14.3	10.6

August

Date: 8/22/2002 **Time:** 1515 PST			**Date:** 8/26/2002 **Time:** 1500 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.9	10.0	0.0	14.1	10.9
0.5	16.9	10.0	0.5	14.1	10.9
1.0	16.9	10.0	1.0	14.0	10.7
1.5	16.9	10.0	1.5	14.0	10.8
2.0	16.9	10.0	2.0	14.0	10.8
Mean	16.9	10.0	Mean	14.0	10.8

September

Date: 9/5/2002 **Time:** 1510 PST			**Date:** 9/27/2002 **Time:** 0810 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	12.6	11.2	0.0	11.6	10.4
0.5	12.5	11.2	0.5	11.6	10.4
1.0	12.5	11.2	1.0	11.6	10.4
1.5	12.5	11.2	1.5	11.6	10.4
2.0	12.5	11.1			
Mean	12.5	11.2	Mean	11.6	10.4

October

Date: 10/9/2002 **Time:** 1510 PST			**Date:** 10/25/2002 **Time:** 1005 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	13.7	10.5	0.0	13.3	10.1
0.5	13.6	10.5	0.5	13.3	10.1
1.0	13.6	10.5	1.0	13.3	10.1
1.5	13.6	10.5			
Mean	13.6	10.5	Mean	13.3	10.1

Pool 1-4
Upstream from Highway 162 Bridge

August

Date: 8/22/2002 **Time:** 1500 PST			**Date:** 8/26/2002 **Time:** 1450 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	18.2	11.1	0.0	15.0	11.0
0.5	18.2	11.1	0.5	15.0	11.1
1.0	18.2	11.2	1.0	14.9	11.0
1.5	18.1	11.2	1.5	14.9	11.0
2.0	18.0	11.2	2.0	14.8	10.9
2.5	18.0	11.3	2.5	14.8	10.9
3.0	18.0	11.2	3.0	14.8	10.9
3.5	18.0	11.1	3.5	14.8	10.9
4.0	17.9	11.0	4.0	14.8	10.8
Mean	18.1	11.2	Mean	14.9	10.9

September

Date: 9/5/2002 **Time:** 1455 PST			**Date:** 9/27/2002 **Time:** 0755 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	14.3	11.2	0.0	11.7	9.2
0.5	14.2	11.4	0.5	11.7	9.1
1.0	14.1	11.7	1.0	11.6	9.1
1.5	14.0	11.9	1.5	11.6	9.1
2.0	14.0	11.9	2.0	11.6	9.1
2.5	13.9	11.8	2.5	11.6	9.1
3.0	13.9	11.8	3.0	11.6	9.0
			3.5	11.6	8.9
Mean	14.1	11.7	Mean	11.6	9.1

October

Date: 10/8/2002 **Time:** 1500 PST			**Date:** 10/25/2002 **Time:** 1050 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	14.9	11.5	0.0	13.4	9.8
0.5	14.8	11.4	0.5	13.4	9.8
1.0	14.8	11.4	1.0	13.3	9.7
1.5	14.7	11.4	1.5	13.3	9.7
2.0	14.6	11.4	2.0	13.3	9.5
2.5	14.6	11.4	2.5	13.3	9.6
3.0	14.6	11.4	3.0	13.3	9.6
3.5	14.6	11.4	3.5	13.3	9.5
Mean	14.7	11.4	Mean	13.3	9.7

Pool 2-1
Upstream from Afterbay Outlet Pool

August

Date: 8/22/2002 Time: 1420 PST			Date: 8/26/2002 Time: 1425 PST		
Depth (m)	Temp. (C)	D.O. (mg/l)	Depth (m)	Temp. (C)	D.O. (mg/l)
0.0	18.5	9.9	0.0	16.5	10.4
0.5	18.5	10.1	0.5	16.4	10.6
1.0	18.4	10.1	1.0	16.3	10.7
1.5	18.4	10.1	1.5	16.2	10.7
2.0	18.4	10.1	2.0	16.2	10.7
2.5	18.3	10.1	2.5	16.2	10.6
3.0	18.3	10.0	3.0	16.2	10.7
3.5	18.3	10.0	3.5	16.2	10.7
4.0	18.3	10.0	4.0	16.2	10.7
4.5	18.3	10.0	4.5	16.2	10.7
			5.0	16.2	10.5
Mean	18.4	10	Mean	16.3	10.6

September

Date: 9/5/2002 Time: 1320 PST			Date: 9/27/2002 Time: 0715 PST		
Depth (m)	Temp. (C)	D.O. (mg/l)	Depth (m)	Temp. (C)	D.O. (mg/l)
0.0	15.0	10.6	0.0	13.3	9.0
0.5	14.9	10.7	0.5	13.3	9.0
1.0	14.9	10.7	1.0	13.3	8.9
1.5	14.9	10.6	1.5	13.3	8.9
2.0	14.9	10.6	2.0	13.3	8.9
2.5	14.8	10.5	2.5	13.3	8.9
3.0	14.8	10.5	3.0	13.3	8.9
3.5	14.8	10.4	3.5	13.3	8.9
4.0	14.8	10.4	4.0	13.3	8.8
4.5	14.8	10.3	4.5	13.3	8.7
5.0	14.8	10.3			
Mean	14.9	10.5	Mean	13.3	8.9

October

Date: 10/8/2002 Time: 1310 PST			Date: 10/24/2002 Time: 1345 PST		
Depth (m)	Temp. (C)	D.O. (mg/l)	Depth (m)	Temp. (C)	D.O. (mg/l)
0.0	15.1	10.4	0.0	13.8	9.9
0.5	15.1	10.4	0.5	13.8	10.0
1.0	15.0	10.5	1.0	13.8	10.0
1.5	15.0	10.5	1.5	13.8	10.0
2.0	15.0	10.5	2.0	13.8	10.0
2.5	15.0	10.4	2.5	13.7	10.0
3.0	15.0	10.4	3.0	13.7	10.0
3.5	14.9	10.4	3.5	13.7	10.0
4.0	14.9	10.3	4.0	13.7	10.1
Mean	15.0	10.4	Mean	13.8	10.0

Pool 2-2
At Afterbay Outlet Pool

August

Date: 8/22/2002 **Time:** 1415 PST			**Date:** 8/26/2002 **Time:** 1410 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.8	10.2	0.0	18.6	10.1
0.5	17.8	10.2	0.5	18.6	10.1
1.0	17.8	10.2	1.0	18.5	10.0
1.5	17.8	10.1	1.5	18.2	10.0
2.0	17.8	10.1	2.0	17.7	10.3
2.5	17.8	10.1	2.5	17.8	10.3
3.0	17.8	10.1	3.0	17.5	10.3
3.5	17.8	10.1	3.5	17.5	10.3
4.0	17.8	10.1	4.0	17.5	10.3
4.5	17.8	10.2	4.5	17.4	10.3
5.0	17.8	10.2	5.0	17.4	10.3
5.5	17.8	10.2	5.5	17.3	10.3
6.0	17.8	10.1	6.0	17.2	10.4
			6.5	17.1	10.3
			7.0	16.8	10.5
Mean	17.8	10.1	Mean	17.7	10.3

September

Date: 9/5/2002 **Time:** 1315 PST			**Date:** 9/27/2002 **Time:** 0645 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.4	10.3	0.0	14.6	10.0
0.5	16.3	10.4	0.5	14.6	10.0
1.0	16.3	10.4	1.0	14.6	10.1
1.5	16.3	10.4	1.5	14.6	10.0
2.0	16.2	10.4	2.0	14.6	10.1
2.5	16.2	10.4	2.5	14.6	10.1
3.0	16.1	10.4	3.0	14.6	10.1
3.5	15.7	10.6	3.5	14.6	10.1
4.0	15.2	10.9	4.0	14.6	10.0
4.5	15.1	10.9	4.5	14.6	10.1
5.0	15.0	10.8	5.0	14.6	10.1
5.5	15.0	10.7	5.5	14.6	10.1
6.0	15.0	10.7			
Mean	15.8	10.6	Mean	14.6	10.1

October

Date: 10/8/2002 **Time:** 1300 PST			**Date:** 10/24/2002 **Time:** 1335 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.0	10.2	0.0	14.6	9.9
0.5	15.9	10.3	0.5	14.6	9.8
1.0	15.9	10.4	1.0	14.6	9.8
1.5	15.9	10.4	1.5	14.6	9.7
2.0	15.9	10.4	2.0	14.6	9.7
2.5	15.9	10.3	2.5	14.6	9.7
3.0	15.8	10.3	3.0	14.6	9.7
3.5	15.8	10.3	3.5	14.6	9.7
4.0	15.8	10.3	4.0	14.6	9.7
4.5	15.8	10.3	4.5	14.6	9.7
5.0	15.8	10.2	5.0	14.6	9.7
			5.5	14.6	9.7
			6.0	14.6	9.7
			6.5	14.6	9.7
			7.0	14.6	9.7
Mean	15.9	10.3	Mean	14.6	9.7

Pool 3-1
Downstream from Afterbay Outlet Pool

August

Date: 8/22/2002 **Time:** 1245 PST			**Date:** 8/26/2002 **Time:** 1245 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.3	10.3	0.0	18.0	10.0
0.5	17.3	10.3	0.5	18.0	10.0
1.0	17.3	10.3	1.0	18.0	10.0
1.5	17.3	10.3	1.5	18.0	10.0
2.0	17.3	10.3	2.0	18.0	9.9
2.5	17.3	10.3	2.5	18.0	9.9
3.0	17.3	10.3			
Mean	17.3	10.3	Mean	18.0	10.0

September

Date: 9/5/2002 **Time:** 1305 PST			**Date:** 9/26/2002 **Time:** 1300 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.8	10.5	0.0	15.8	10.9
0.5	16.7	10.5	0.5	15.7	10.9
1.0	16.7	10.5	1.0	15.7	10.9
1.5	16.7	10.5	1.5	15.7	10.9
2.0	16.7	10.5	2.0	15.7	10.8
2.5	16.7	10.4	2.5	15.7	10.8
3.0	16.7	10.4	3.0	15.7	10.8
			3.5	15.7	10.7
Mean	16.7	10.5	Mean	15.7	10.1

October

Date: 10/8/2002 **Time:** 1245 PST			**Date:** 10/24/2002 **Time:** 1330 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.0	10.6	0.0	14.6	9.9
0.5	15.9	10.6	0.5	14.6	9.9
1.0	15.7	10.6	1.0	14.6	9.9
1.5	15.9	10.6	1.5	14.6	9.9
2.0	15.9	10.5	2.0	14.6	9.9
Mean	15.9	10.6	Mean	14.6	9.9

Pool 3-2
Near Mile Long Pool

August

Date: 8/22/2002 **Time:** 1235 PST			**Date:** 8/26/2002 **Time:** 1235 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.6	10.6	0.0	18.8	9.7
0.5	17.6	10.6	0.5	18.7	9.7
1.0	17.6	10.6	1.0	18.7	9.7
1.5	17.6	10.6	1.5	18.7	9.6
2.0	17.5	10.6	2.0	18.7	9.6
2.5	17.5	10.6	2.5	18.7	9.6
Mean	17.6	10.6	Mean	18.7	9.7

September

Date: 9/5/2002 **Time:** 1255 PST			**Date:** 9/26/2002 **Time:** 1255 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.3	10.2	0.0	16.3	10.6
0.5	17.2	10.4	0.5	16.3	10.6
1.0	17.2	10.4	1.0	16.2	10.5
1.5	17.2	10.3	1.5	16.2	10.5
2.0	17.2	10.3			
Mean	17.2	10.3	Mean	16.3	10.6

October

Date: 10/8/2002 **Time:** 1230 PST			**Date:** 10/24/2002 **Time:** 1315 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.8	10.2	0.0	14.8	9.6
0.5	16.7	10.2	0.5	14.8	9.6
1.0	16.5	10.5	1.0	14.8	9.7
1.5	16.4	10.5	1.5	14.8	9.8
Mean	16.6	10.4	Mean	14.8	9.7

Pool 3-3
Downstream from Project Boundary Pool

August

Date: 8/22/2002 **Time:** 1500 PST			**Date:** 8/26/2002 **Time:** 1220 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.9	10.8	0.0	18.8	10.2
0.5	17.9	10.7	0.5	18.8	10.2
1.0	17.8	10.7	1.0	18.8	10.2
1.5	17.8	10.7	1.5	18.7	10.2
2.0	17.8	10.6	2.0	18.7	10.2
2.5	17.8	10.6	2.5	18.7	10.1
3.0	17.8	10.6	3.0	18.7	10.0
3.5	17.8	10.6	3.5	18.7	10.0
4.0	17.8	10.6	4.0	18.7	10.0
Mean	17.8	10.6	Mean	18.7	10.1

September

Date: 9/5/2002 **Time:** 1245 PST			**Date:** 9/26/2002 **Time:** 1240 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.5	10.8	0.0	16.8	11.2
0.5	17.4	10.8	0.5	16.8	11.2
1.0	17.4	10.8	1.0	16.7	11.2
1.5	17.4	10.8	1.5	16.7	11.1
2.0	17.4	10.8	2.0	16.8	11.1
2.5	17.3	10.7	2.5	16.8	11.0
3.0	17.3	10.7	3.0	16.8	11.0
3.5	17.3	10.7	3.5	16.8	11.0
4.0	17.3	10.7	4.0	16.7	11.0
4.5	17.3	10.7			
Mean	17.4	10.8	Mean	16.8	11.1

October

Date: 10/8/2002 **Time:** 1220 PST			**Date:** 10/24/2002 **Time:** 1300 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.9	10.6	0.0	15.0	9.9
0.5	16.8	10.7	0.5	15.0	10.0
1.0	16.8	10.7	1.0	15.0	10.1
1.5	16.7	10.7	1.5	15.0	10.1
2.0	16.7	10.6	2.0	15.0	10.1
2.5	16.7	10.6	2.5	15.0	10.1
3.0	16.7	10.6	3.0	15.0	10.1
3.5	16.7	10.6	3.5	15.0	10.1
4.0	16.7	10.4	4.0	15.0	10.1
4.25	16.7	10.2			
Mean	16.7	10.6	Mean	15.0	9.9

Pool 3-4
Near Gridley Pool

August

Date: 8/22/2002 **Time:** 1205 PST			**Date:** 8/26/2002 **Time:** 1205 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.8	10.6	0.0	19.1	9.7
0.5	17.8	10.6	0.5	19.1	9.7
1.0	17.8	10.6	1.0	19.0	9.7
1.5	17.8	10.6	1.5	19.0	9.7
2.0	17.7	10.5	2.0	19.0	9.8
2.5	17.7	10.5	2.5	19.0	9.7
3.0	17.7	10.5	3.0	19.0	9.7
3.5	17.7	10.5	3.5	19.0	9.7
4.0	17.7	10.5	4.0	19.0	9.7
4.5	17.7	10.5	4.5	19.0	9.7
Mean	17.7	10.5	Mean	19	9.7

September

Date: 9/5/2002 **Time:** 1230 PST			**Date:** 9/26/2002 **Time:** 1230 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.3	10.4	0.0	16.8	10.8
0.5	17.2	10.5	0.5	16.8	10.7
1.0	17.2	10.5	1.0	16.8	10.7
1.5	17.2	10.6	1.5	16.7	10.7
2.0	17.2	10.6	2.0	16.7	10.7
2.5	17.1	10.6	2.5	16.7	10.7
3.0	17.1	10.6	3.0	16.7	10.7
3.5	17.1	10.6	3.5	16.7	10.7
4.0	17.1	10.6	4.0	16.7	10.7
4.5	17.0	10.5	4.5	16.7	10.7
5.0	17.1	10.1	5.0	16.7	10.7
5.5	17.1	10.1			
Mean	17.1	10.5	Mean	16.8	10.7

October

Date: 10/8/2002 **Time:** 1200 PST			**Date:** 10/24/2002 **Time:** 1245 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.6	10.2	0.0	14.8	9.8
0.5	16.6	10.1	0.5	14.8	9.8
1.0	16.6	10.1	1.0	14.8	9.8
1.5	16.6	10.1	1.5	14.8	9.8
2.0	16.5	10.1	2.0	14.8	9.8
2.5	16.5	10.1	2.5	14.8	9.8
3.0	16.5	10.1	3.0	14.8	9.8
3.5	16.5	10.1	3.5	14.8	9.8
4.0	16.5	10.1	4.0	14.8	9.8
4.5	16.5	10.1	4.5	14.8	9.7
			5.0	14.8	9.7
Mean	16.5	10.1	Mean	14.8	9.9

Pool 3-5
Upstream from Honcut Creek

August

Date: 8/22/2002 **Time:** 1150 PST			**Date:** 8/26/2002 **Time:** 1150 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.8	9.9	0.0	19.3	9.2
0.5	17.8	9.9	0.5	19.3	9.1
1.0	17.7	9.9	1.0	19.2	9.1
1.5	17.7	9.9	1.5	19.2	8.9
2.0	17.7	9.8	2.0	19.2	8.8
2.5	17.7	9.8	2.5	19.2	9.0
3.0	17.7	9.8	3.0	19.2	9.0
Mean	17.7	9.9	Mean	19.2	9.0

September

Date: 9/5/2002 **Time:** 1215 PST			**Date:** 9/26/2002 **Time:** 1210 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.8	9.9	0.0	16.8	9.5
0.5	16.8	9.9	0.5	16.7	9.7
1.0	16.8	10.0	1.0	16.7	9.7
1.5	16.8	10.0	1.5	16.6	9.7
2.0	16.8	10.0	2.0	16.5	9.8
2.5	16.8	10.0	2.5	16.5	9.8
3.0	16.8	9.9	3.0	16.5	9.7
			3.5	16.5	9.8
Mean	16.8	10.0	Mean	16.6	9.7

October

Date: 10/8/2002 **Time:** 1145 PST			**Date:** 10/24/2002 **Time:** 1230 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.5	9.0	0.0	14.7	8.9
0.5	16.4	9.3	0.5	14.7	8.8
1.0	16.3	9.3	1.0	14.7	8.8
1.5	16.3	9.2	1.5	14.7	8.8
2.0	16.2	9.2	2.0	14.7	8.8
2.5	16.2	9.1	2.5	14.7	8.8
3.0	16.2	9.0			
Mean	16.3	9.2	Mean	14.7	8.8

Pool 4-1
At Archer Avenue Pool

August

Date: 8/22/2002 **Time:** 1130 PST			**Date:** 8/26/2002 **Time:** 1130 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	18.0	9.6	0.0	19.6	8.8
0.5	18.0	9.6	0.5	19.6	8.8
1.0	17.9	9.6	1.0	19.5	8.8
1.5	17.9	9.6	1.5	19.5	8.8
2.0	17.9	9.6	2.0	19.5	8.7
2.5	17.9	9.6			
3.0	17.9	9.6			
Mean	17.9	9.6	Mean	19.5	8.8

September

Date: 9/5/2002 **Time:** 1200 PST			**Date:** 9/26/2002 **Time:** 1150 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.8	9.7	0.0	16.8	9.8
0.5	16.8	9.7	0.5	16.7	9.7
1.0	16.8	9.7	1.0	16.7	9.7
1.5	16.8	9.6	1.5	16.7	9.7
2.0	16.8	9.6	2.0	16.7	9.7
2.5	16.8	9.5	2.5	16.7	9.7
			3.0	16.7	9.7
Mean	16.8	9.6	Mean	16.7	9.7

October

Date: 10/8/2002 **Time:** 1130 PST			**Date:** 10/24/2002 **Time:** 1205 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	16.7	9.5	0.0	15.0	9.2
0.5	16.6	9.5	0.5	15.0	9.2
1.0	16.6	9.5	1.0	15.0	9.1
1.5	16.6	9.5	1.5	15.0	9.1
2.0	16.6	9.5	2.0	15.0	9.1
2.5	16.6	9.5	2.5	15.0	9.1
			3.0	15.0	9.1
			3.5	15.0	9.1
			4.0	15.0	9.1
			4.5	15.0	9.1
			5.0	15.0	9.1
Mean	16.6	9.5	Mean	15.0	9.1

Pool 4-2
Upstream from Yuba River Pool

August

Date: 8/07/2002 **Time:** 1240 PST			**Date:** 8/22/2002 **Time:** 1100 PST			**Date:** 8/26/2002 **Time:** 1100 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	20.1	9.2	0.0	18.6	9.1	0.0	20.2	8.6
0.5	20.1	9.1	0.5	18.6	9.1	0.5	20.1	8.6
1.0	20.0	9.1	1.0	18.6	9.1	1.0	20.1	8.6
1.5	20.0	9.1	1.5	18.6	9.1	1.5	20.1	8.6
2.0	20.0	9.1	2.0	18.6	9.1			
Mean	20.0	9.1	Mean	18.6	9.1	Mean	20.1	8.6

September

Date: 9/5/2002 **Time:** 0955 PST			**Date:** 9/26/2002 **Time:** 1110 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.3	9.3	0.0	18.0	9.3
0.5	17.3	9.3	0.5	17.9	9.3
1.0	17.2	9.4	1.0	17.9	9.3
1.5	17.2	9.4	1.5	17.9	9.3
2.0	17.2	9.4			
Mean	17.2	9.4	Mean	17.9	9.3

October

Date: 10/8/2002 **Time:** 1045 PST			**Date:** 10/24/2002 **Time:** 1100 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.0	9.4	0.0	14.9	8.8
0.5	17.0	9.4	0.5	14.9	8.8
1.0	17.0	9.4	1.0	14.9	8.8
1.5	17.0	9.4	1.5	14.9	8.8
Mean	17.0	9.4	Mean	14.9	8.8

Pool 4-3
At Shanghai Bend Pool

August

Date: 8/07/2002 **Time:** 1100 PST			**Date:** 8/22/2002 **Time:** 1015 PST			**Date:** 8/26/2002 **Time:** 1015 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	18.8	9.5	0.0	18.5	9.1	0.0	19.5	8.6
0.5	18.8	9.5	0.5	18.5	9.1	0.5	19.5	8.6
1.0	18.7	9.4	1.0	18.5	9.0	1.0	19.5	8.6
1.5	18.7	9.4	1.5	18.5	9.0	1.5	19.4	8.6
2.0	18.7	9.4	2.0	18.5	9.0	2.0	19.4	8.6
2.5	18.7	9.4	2.5	18.5	9.0	2.5	19.4	8.6
3.0	18.7	9.4	3.0	18.5	9.0	3.0	19.4	8.6
3.5	18.7	9.4	3.5	18.4	8.9	3.5	19.4	8.6
4.0	18.7	9.4	4.0	18.4	8.9	4.0	19.4	8.6
4.5	18.6	9.3				4.5	19.4	8.5
Mean	18.7	9.4	Mean	18.5	9.0	Mean	19.4	8.6

September

Date: 9/5/2002 **Time:** 1050 PST			**Date:** 9/26/2002 **Time:** 1030 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.5	9.3	0.0	18.0	9.3
0.5	17.5	9.3	0.5	18.0	9.3
1.0	17.5	9.4	1.0	18.0	9.3
1.5	17.5	9.4	1.5	18.0	9.3
2.0	17.4	9.1	2.0	18.0	9.2
2.5	17.4	9.3	2.5	18.0	9.1
3.0	17.4	9.3	3.0	18.0	9.1
3.5	17.4	9.3	3.5	18.0	9.1
4.0	17.4	9.2			
4.5	17.4	9.2			
5.0	17.4	9.4			
Mean	17.4	9.3	Mean	18.0	9.2

October

Date: 10/8/2002 **Time:** 0955 PST			**Date:** 10/24/2002 **Time:** 1000 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.0	9.4	0.0	14.8	9.2
0.5	17.0	9.4	0.5	14.8	9.2
1.0	17.0	9.4	1.0	14.8	9.2
1.5	17.0	9.5	1.5	14.8	9.2
2.0	17.0	9.4	2.0	14.8	9.2
2.5	17.0	9.3	2.5	14.8	9.2
3.0	17.0	9.3	3.0	14.8	9.2
3.5	17.0	9.3	3.5	14.8	9.1
4.0	17.0	9.3	4.0	14.8	9.0
4.5	17.0	9.2			
Mean	17.0	9.4	Mean	14.8	9.2

Pool 4-4
At Star Bend Pool

August

Date: 8/07/2002 **Time:** 1035 PST			**Date:** 8/22/2002 **Time:** 0950 PST			**Date:** 8/26/2002 **Time:** 0945 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	19.1	9.3	0.0	18.9	9.2	0.0	19.7	8.7
0.5	19.1	9.3	0.5	18.9	9.2	0.5	19.7	8.7
1.0	19.1	9.3	1.0	18.9	9.2	1.0	19.7	8.7
1.5	19.1	9.4	1.5	18.9	9.2	1.5	19.7	8.7
2.0	19.1	9.4	2.0	18.9	9.2	2.0	19.7	8.7
2.5	19.1	9.4	2.5	18.9	9.2	2.5	19.7	8.7
3.0	19.1	9.4	3.0	18.9	9.2	3.0	19.7	8.6
3.5	19.1	9.4	3.5	18.9	9.2	3.5	19.7	8.6
4.0	19.1	9.4	4.0	18.9	9.2	4.0	19.6	8.8
4.5	19.1	9.4	4.5	18.9	9.2	4.5	19.6	8.7
5.0	19.1	9.4	5.0	18.9	9.2	5.0	19.6	8.7
5.5	19.2	9.4	5.5	18.9	9.2	5.5	19.6	8.7
			6.0	18.9	9.2	6.0	19.6	8.7
			6.5	18.9	9.2			
			7.0	18.9	9.1			
Mean	19.1	9.4	Mean	18.9	9.2	Mean	19.7	8.7

September

Date: 9/5/2002 **Time:** 1030 PST			**Date:** 9/26/2002 **Time:** 1005 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.8	9.5	0.0	17.9	9.3
0.5	17.7	9.5	0.5	17.9	9.3
1.0	17.7	9.5	1.0	17.9	9.3
1.5	17.7	9.5	1.5	17.9	9.3
2.0	17.7	9.5	2.0	17.9	9.4
2.5	17.7	9.5	2.5	17.9	9.3
3.0	17.7	9.5	3.0	17.9	9.3
3.5	17.7	9.5	3.5	17.9	9.3
4.0	17.7	9.5	4.0	17.9	9.2
4.5	17.7	9.5			
5.0	17.7	9.5			
5.5	17.7	9.5			
6.0	17.7	9.3			
6.5	17.7	9.3			
Mean	17.7	9.5	Mean	17.9	9.3

October

Date: 10/8/2002 **Time:** 0930 PST			**Date:** 10/24/2002 **Time:** 0930 PST		
Depth (m)	**Temp. (C)**	**D.O. (mg/l)**	**Depth (m)**	**Temp. (C)**	**D.O. (mg/l)**
0.0	17.2	9.4	0.0	15.1	9.3
0.5	17.2	9.4	0.5	15.1	9.2
1.0	17.2	9.4	1.0	15.1	9.3
1.5	17.2	9.4	1.5	15.1	9.3
2.0	17.2	9.4	2.0	15.1	9.3
2.5	17.2	9.3	2.5	15.1	9.3
3.0	17.2	9.4	3.0	15.1	9.3
3.5	17.2	9.4	3.5	15.1	9.3
4.0	17.2	9.4	4.0	15.1	9.3
4.5	17.2	9.4	4.5	15.1	9.3
5.0	17.2	9.4	5.0	15.1	9.3
			5.5	15.1	9.3
			6.0	15.1	9.3
Mean	17.2	9.4	Mean	15.1	9.3

Pool 4-5
Near Verona Pool

August

Date: 8/07/2002 Time: 0900 PST			Date: 8/22/2002 Time: 0830 PST			Date: 8/26/2002 Time: 0830 PST		
Depth (m)	Temp. (C)	D.O. (mg/l)	Depth (m)	Temp. (C)	D.O. (mg/l)	Depth (m)	Temp. (C)	D.O. (mg/l)
0.0	19.2	9.1	0.0	18.9	8.8	0.0	19.7	8.6
0.5	19.2	9.1	0.5	18.9	8.8	0.5	19.7	8.6
1.0	19.2	9.1	1.0	18.9	8.8	1.0	19.7	8.6
1.5	19.2	9.1	1.5	18.9	8.8	1.5	19.7	8.6
2.0	19.2	9.1	2.0	18.9	8.8	2.0	19.7	8.6
2.5	19.2	9.1						
Mean	19.2	9.1	Mean	18.9	8.8	Mean	19.7	8.6

September

Date: 9/5/2002 Time: 0840 PST			Date: 9/26/2002 Time: 0900 PST		
Depth (m)	Temp. (C)	D.O. (mg/l)	Depth (m)	Temp. (C)	D.O. (mg/l)
0.0	18.5	8.9	0.0	18.8	8.9
0.5	18.5	8.9	0.5	18.8	8.9
1.0	18.5	8.9	1.0	18.8	8.9
1.5	18.5	8.8	1.5	18.8	8.9
2.0	18.5	8.8			
2.5	18.5	8.8			
3.0	18.5	8.8			
3.5	18.5	8.8			
Mean	18.5	8.8	Mean	18.8	8.9

October

Date: 10/8/2002 Time: 0930 PST			Date: 10/24/2002 Time: 0930 PST		
Depth (m)	Temp. (C)	D.O. (mg/l)	Depth (m)	Temp. (C)	D.O. (mg/l)
0.0	17.8	9.2	0.0	14.8	9.4
0.5	17.8	9.2	0.5	14.8	9.4
1.0	17.8	9.2	1.0	14.8	9.4
1.5	17.8	9.2			
Mean	17.8	9.2	Mean	14.8	9.4

OROVILLE FERC RELICENSING
(PROJECT NO. 2100)

INTERIM REPORT
SP-F10, Task 1E

APPENDIX B
MEAN WATER TEMPERATURE IN FEATHER RIVER POOLS

APRIL 2003

Feather River Downstream from Fish Barrier Dam
N 39° 31' 8.5" W 121° 32' 53"
Pool 1-1

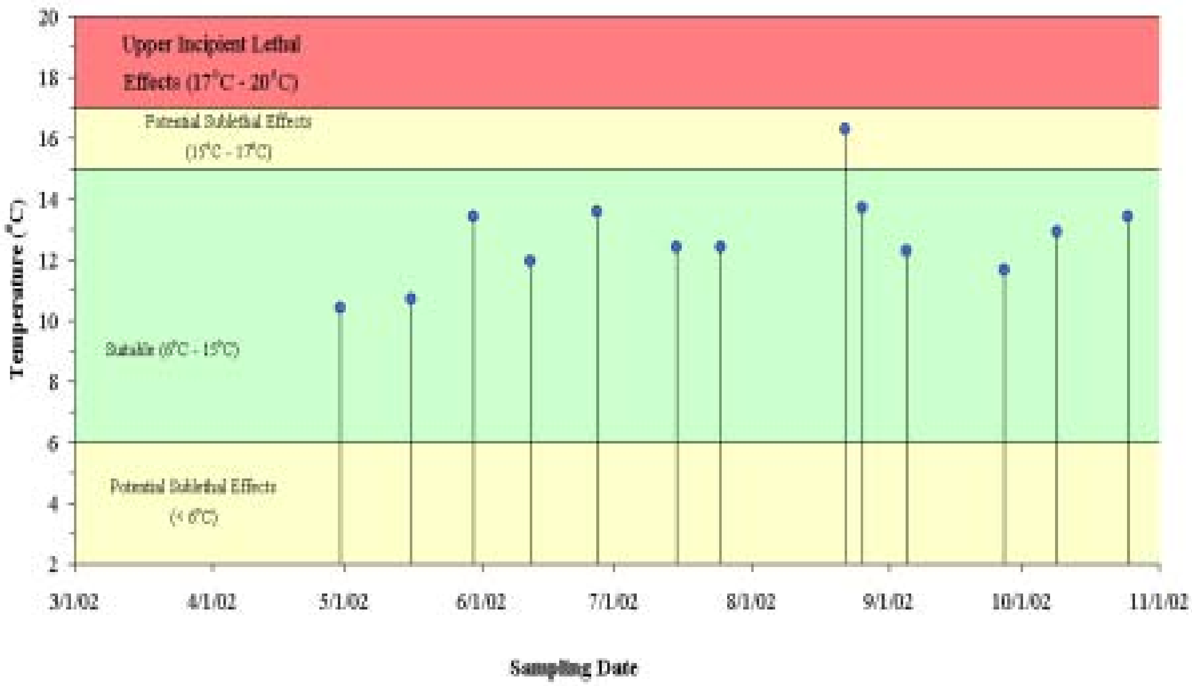

Figure B-1. Water Column Temperature at Feather River Downstream from Fish Barrier Dam.

Feather River Upstream from Hatchery
N 39° 31' 3.5" W 121° 33' 1.2"
Pool 1-2

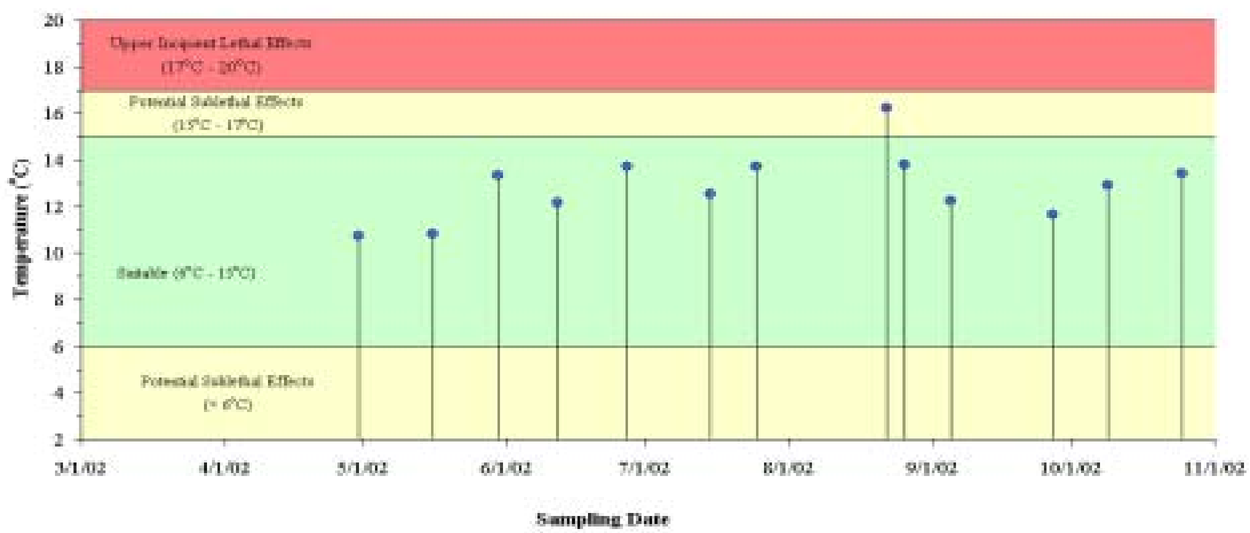

Figure B-2. Water Column Temperature at Feather River Upstream from Hatchery

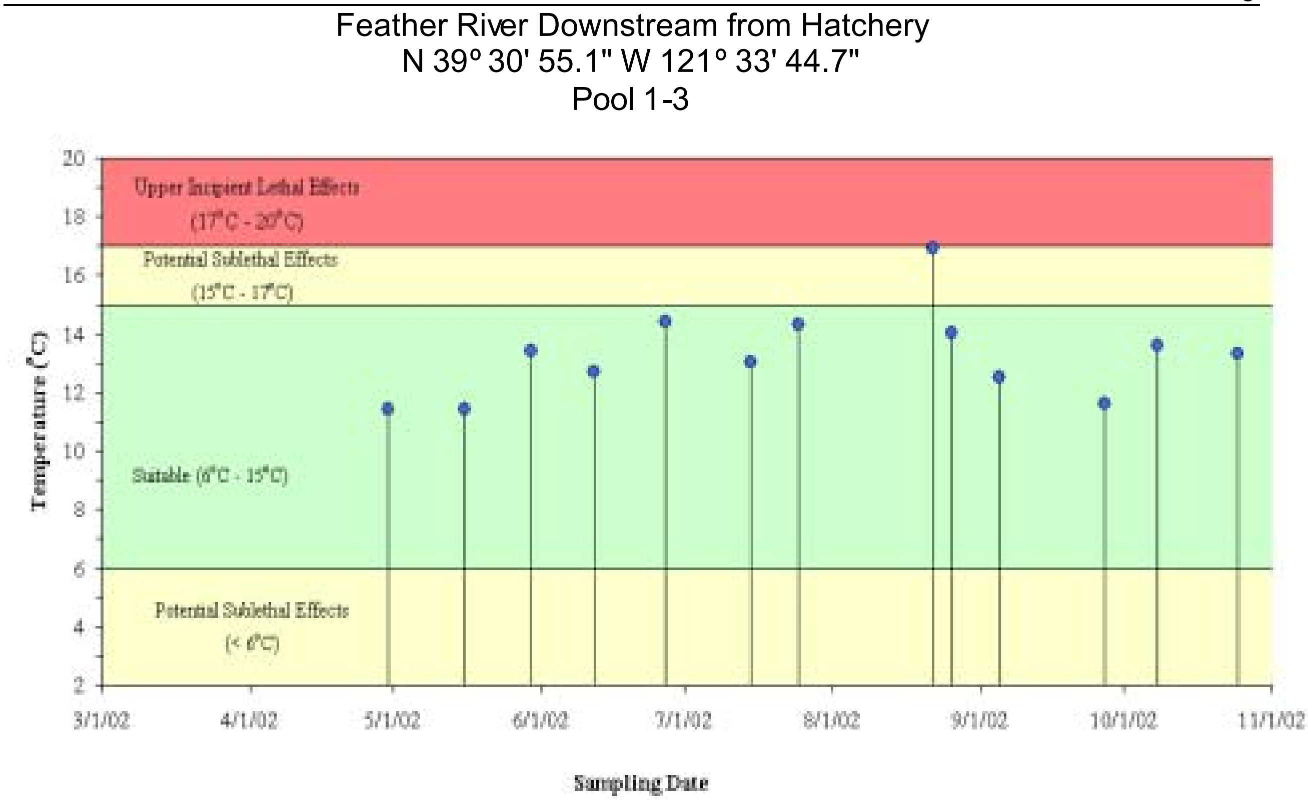

Figure B-3. Water Column Temperature at Feather River Downstream from Hatchery

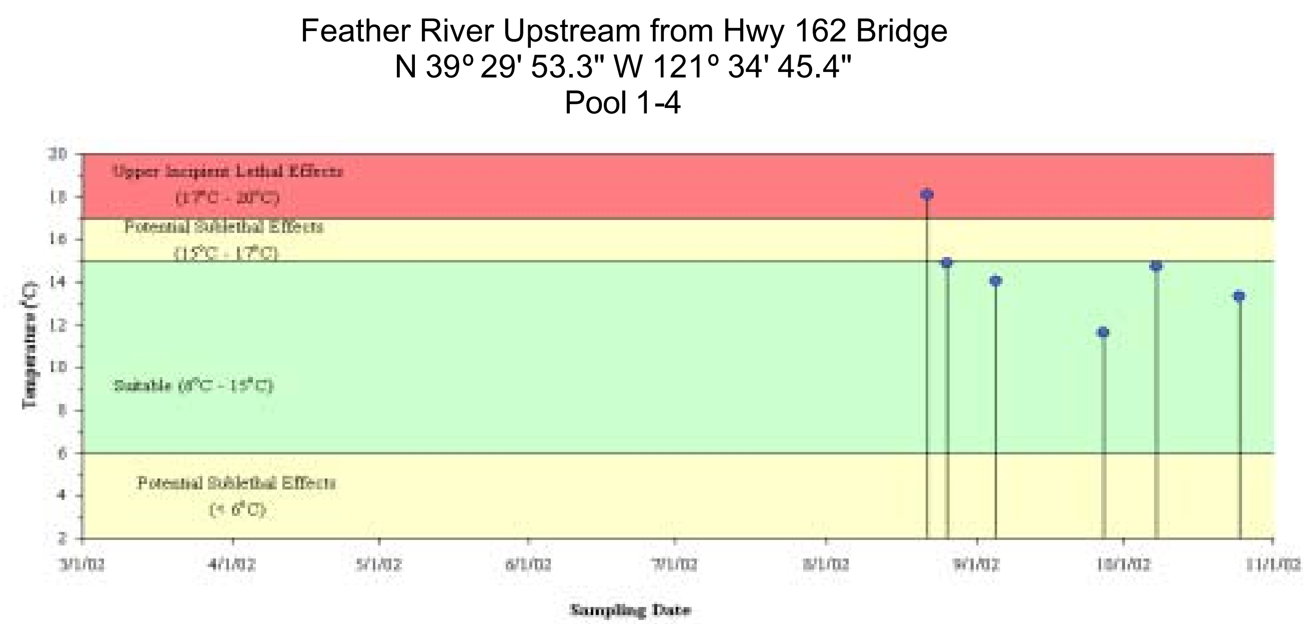

Figure B-4. Water Column Temperature at Feather River Upstream from Hwy 162 Bridge.

Feather River Upstream Afterbay Outlet
N 39° 27' 23.4" W 121° 37' 13.5"
Pool 2-1

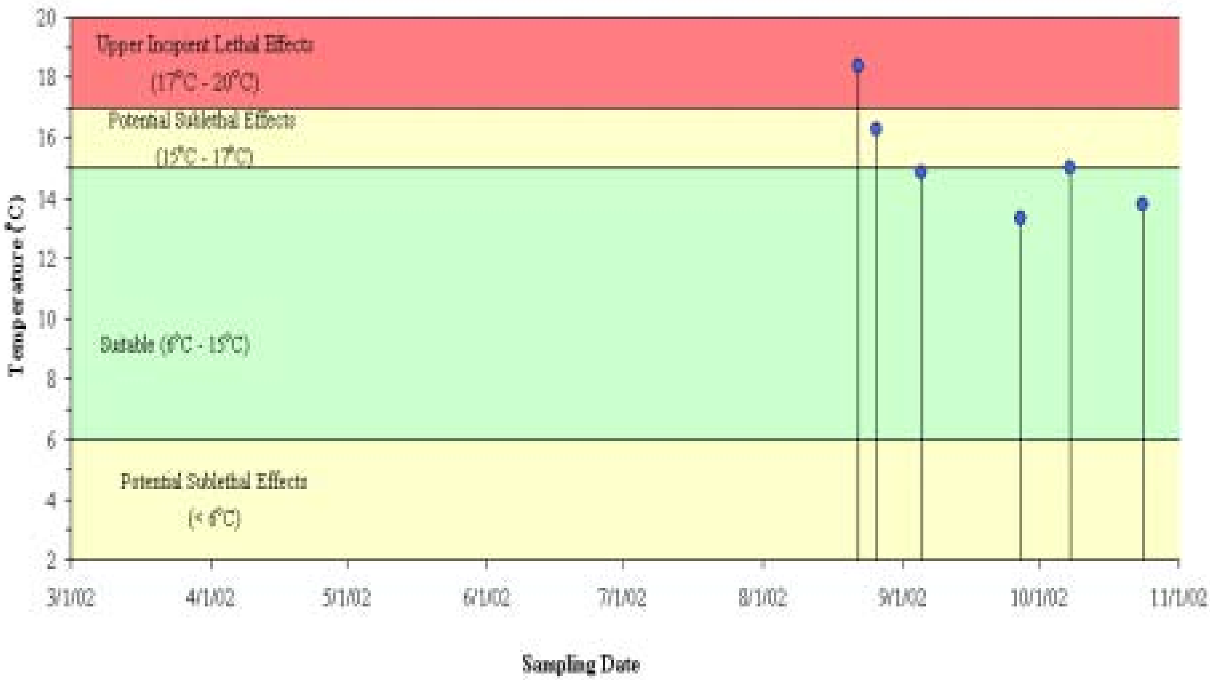

Figure B-5. Water Column Temperature at Feather River Upstream from Afterbay Outlet.

Feather River at Afterbay Outlet
N 39° 27' 18.2" W 121° 38' 10.5"
Pool 2-2

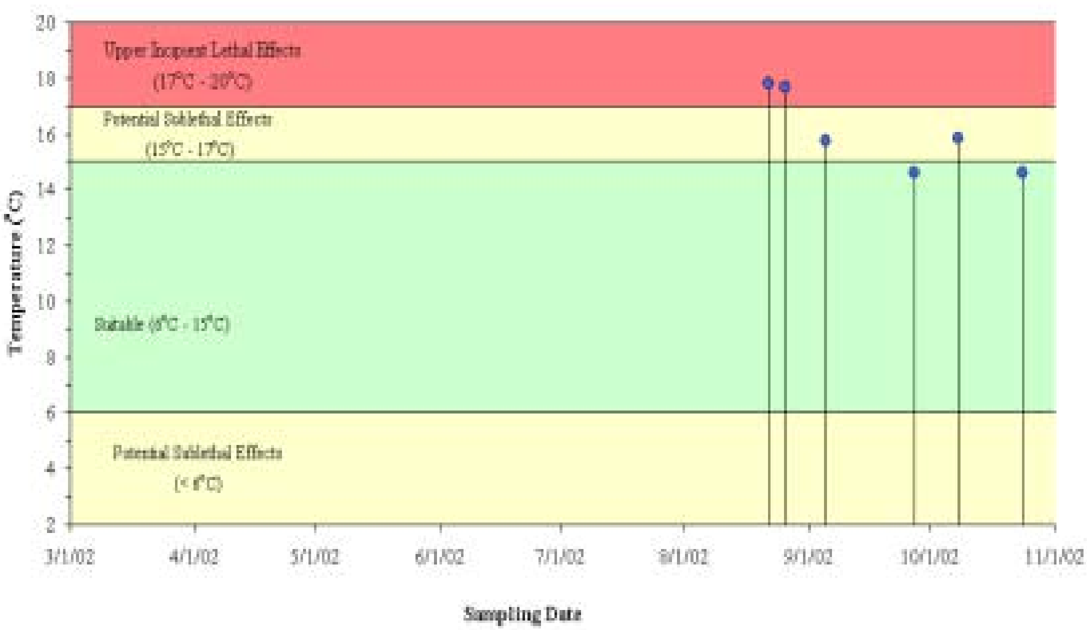

Figure B-6. Water Column Temperature at Feather River at Afterbay Outlet.

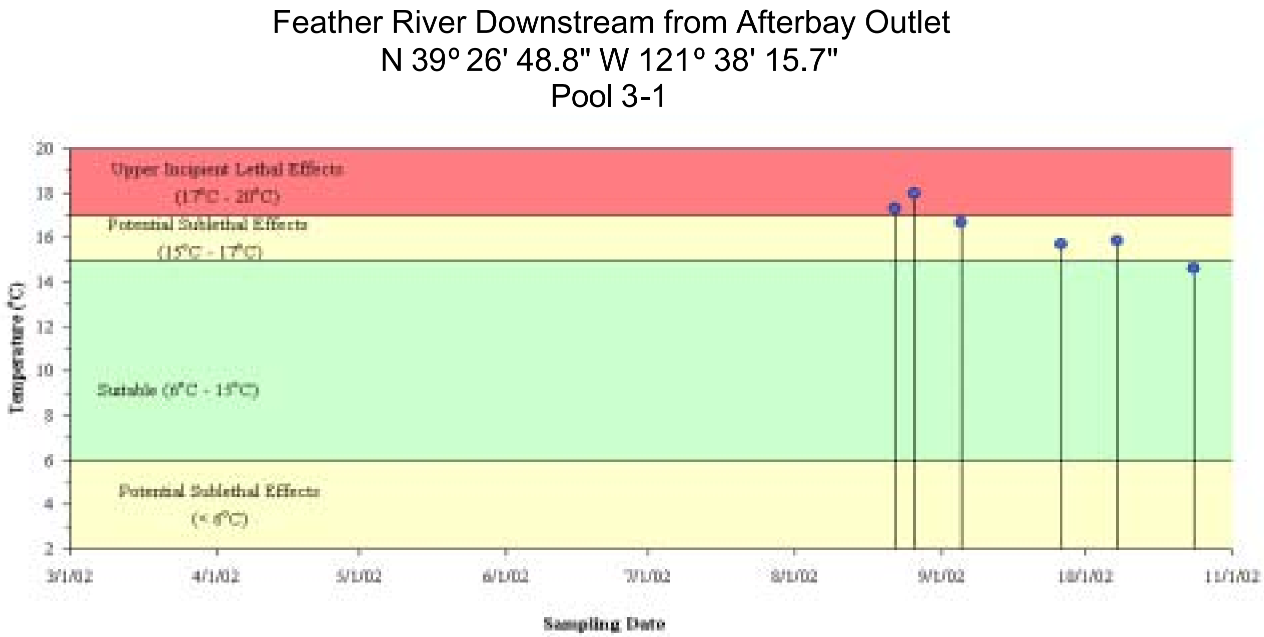

Figure B-7. Water Column Temperature at Feather River Downstream from Afterbay Outlet.

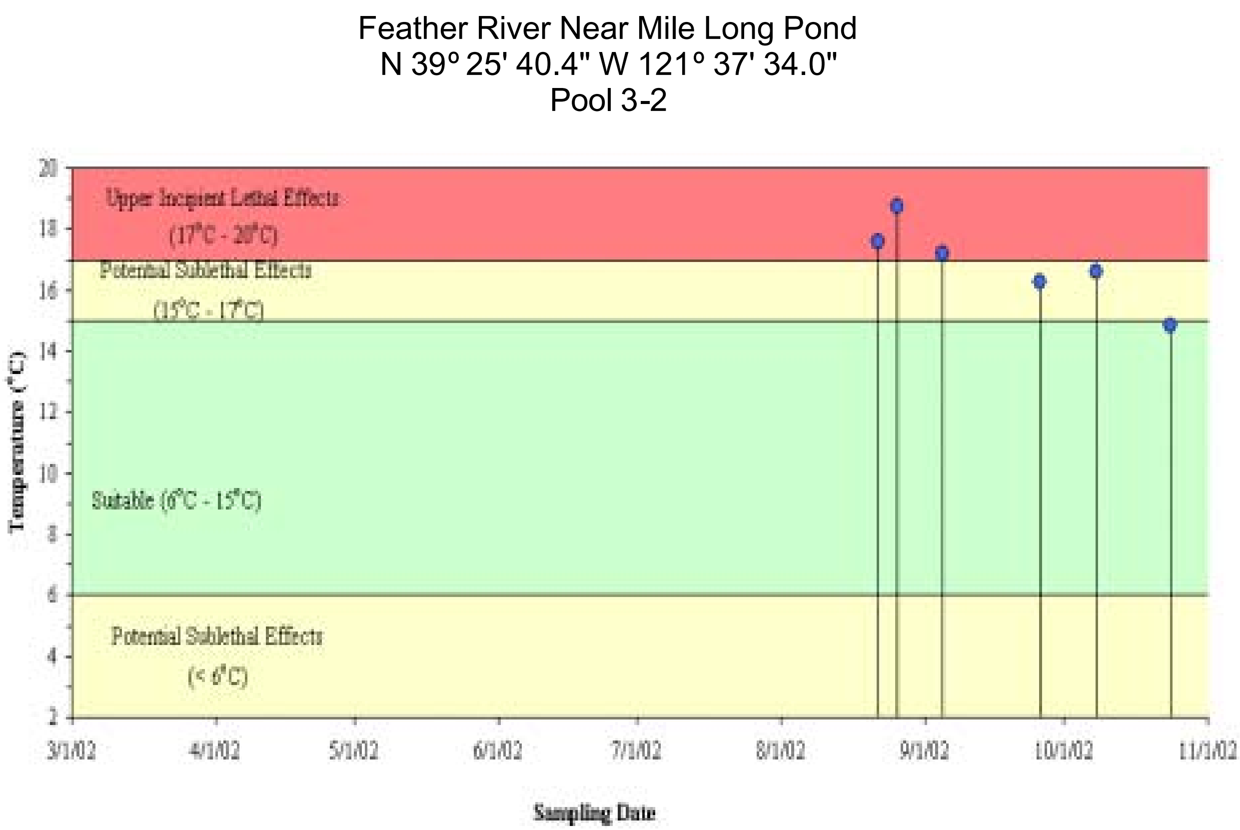

Figure B-8. Water Column Temperature at Feather River Near Mile Long Pond.

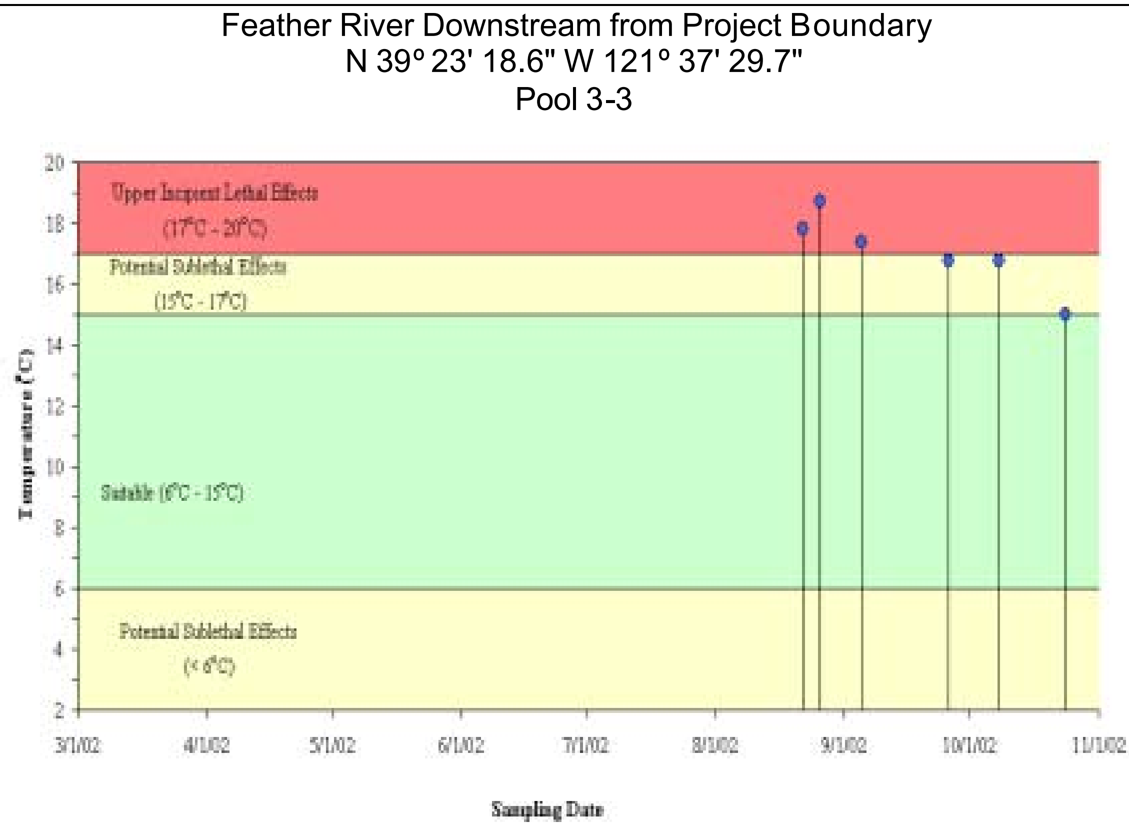

Figure B-9. Water Column Temperature at Feather River Downstream from Project Boundary.

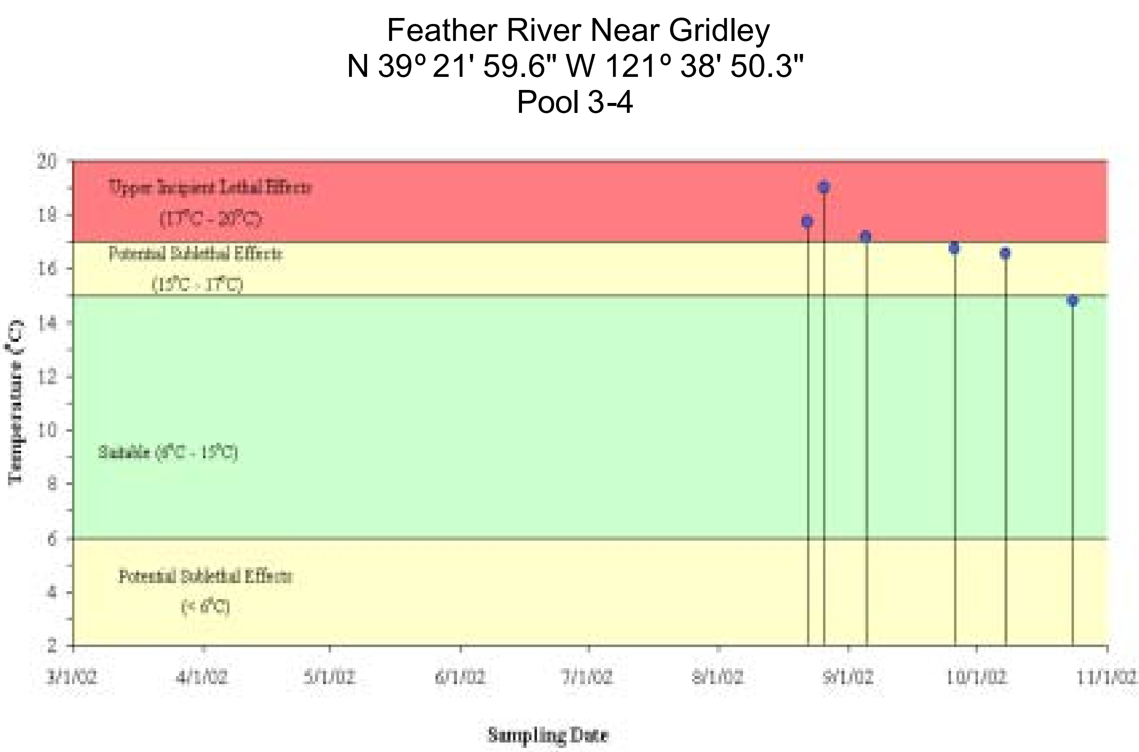

Figure B-10. Water Column Temperature at Feather River Near Gridley.

Feather River Upstream from Honcut Creek
N 39º 19' 39.5" W 121º 37' 32.9"
Pool 3-5

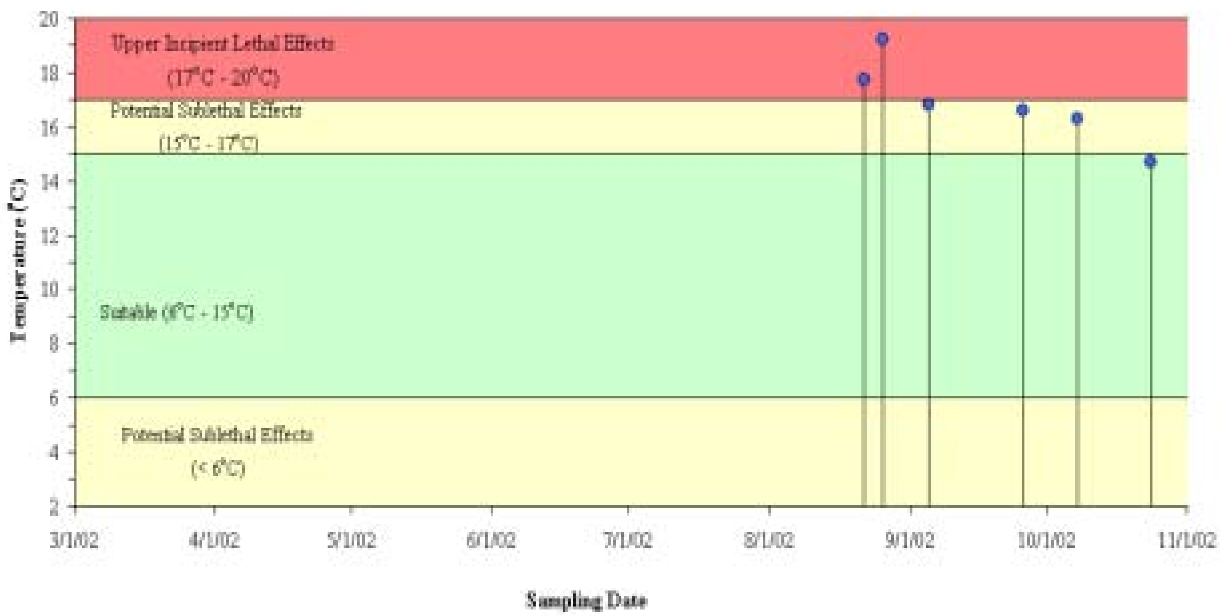

Figure B-11. Water Column Temperature at Feather River Upstream from Honcut Creek.

Feather River Near Live Oak
N 39º 16' 21.4" W 121º 37' 55.0"
Pool 4-1

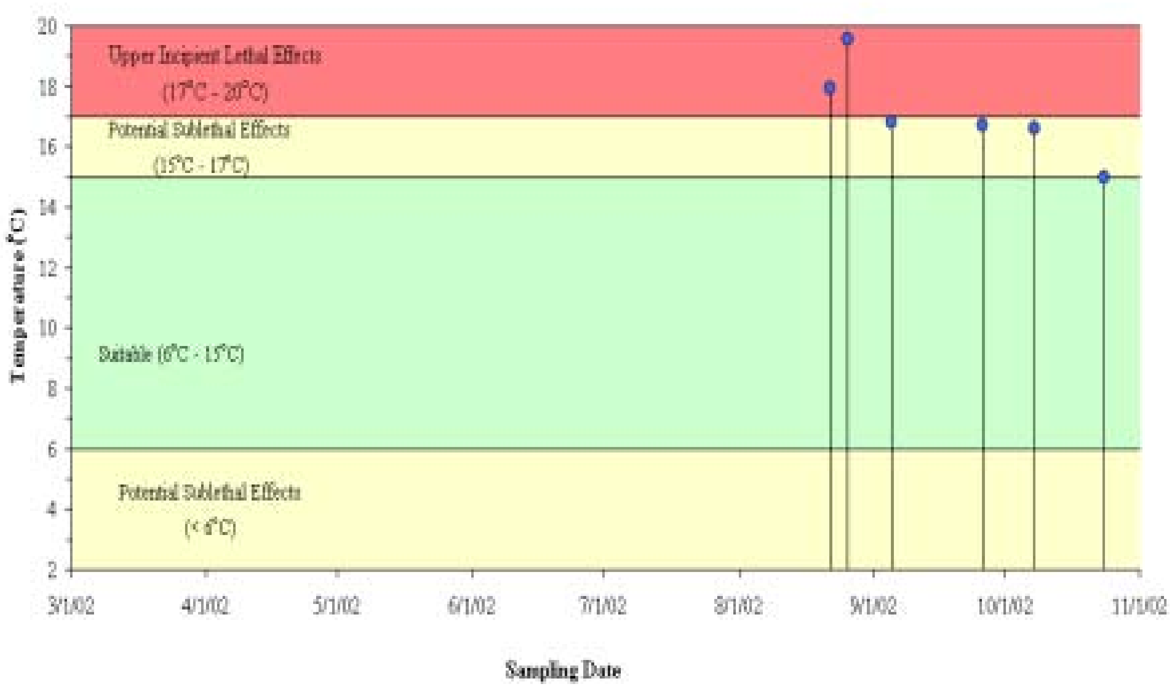

Figure B-12. Water Column Temperature at Feather River Near Live Oak.

Feather River Upstream from Confluence with Yuba River
N 39° 7' 50.3" W 121° 35' 57.8"
Pool 4-2

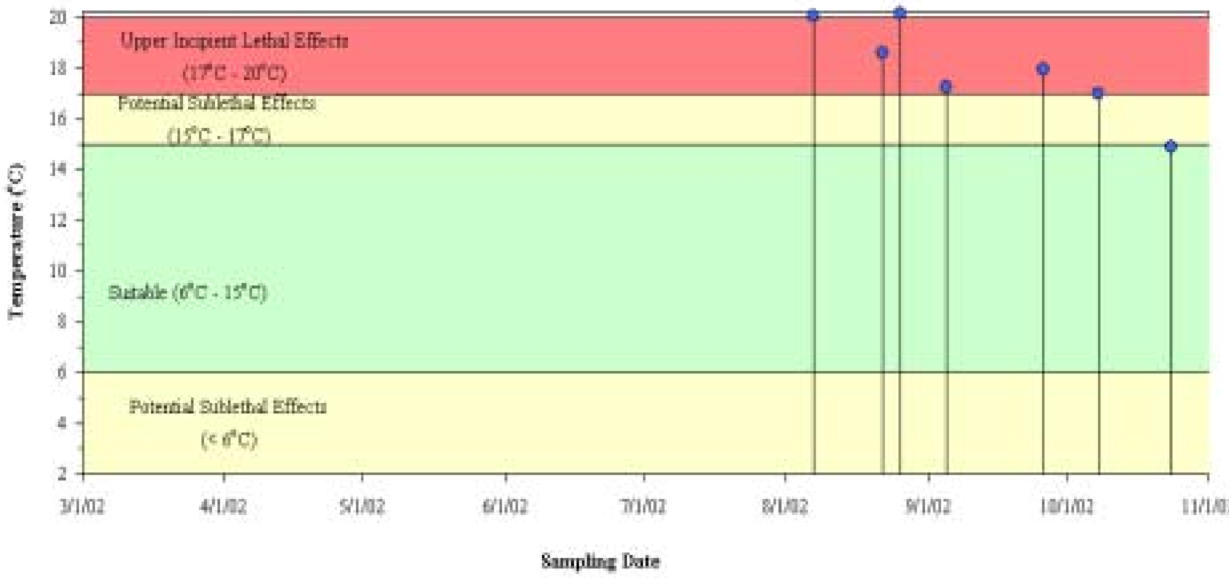

Figure B-13. Water Column Temperature at Feather River Upstream from Confluence with Yuba River.

Feather River Near Shanghai Bend
N 39° 5' 22.4" W 121° 35' 59.1"
Pool 4-3

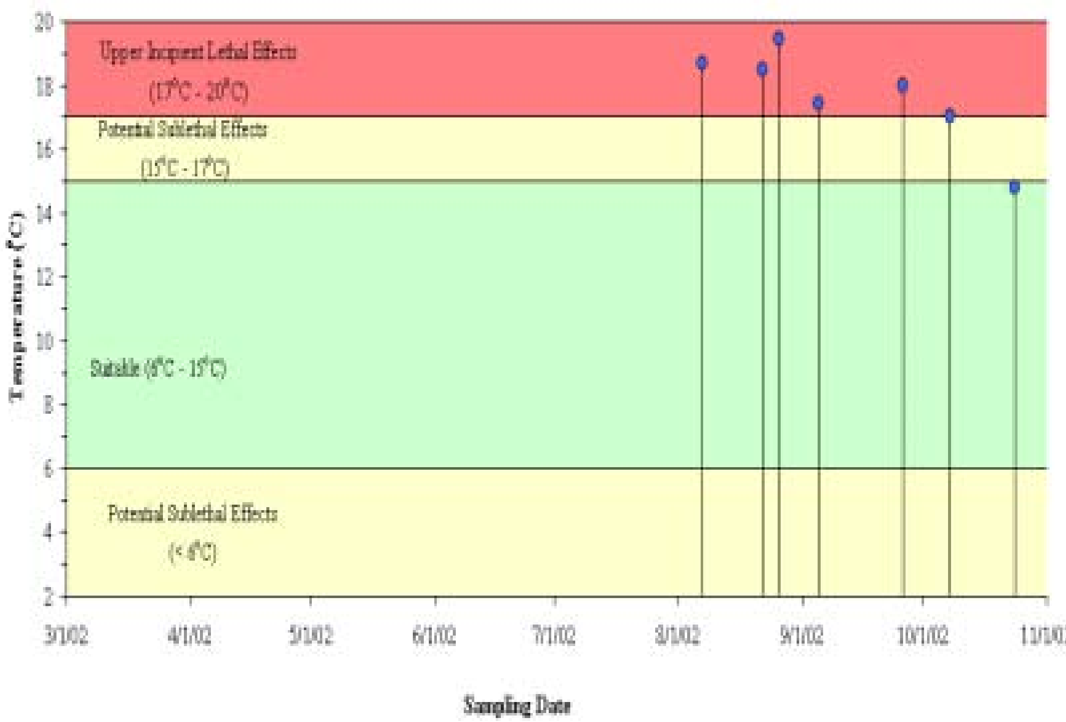

Figure B-14. Water Column Temperature at Feather River Near Shanghai Bend.

Feather River at Star Bend
N 39º 0' 42.0" W 121º 35' 57.3"
Pool 4-4

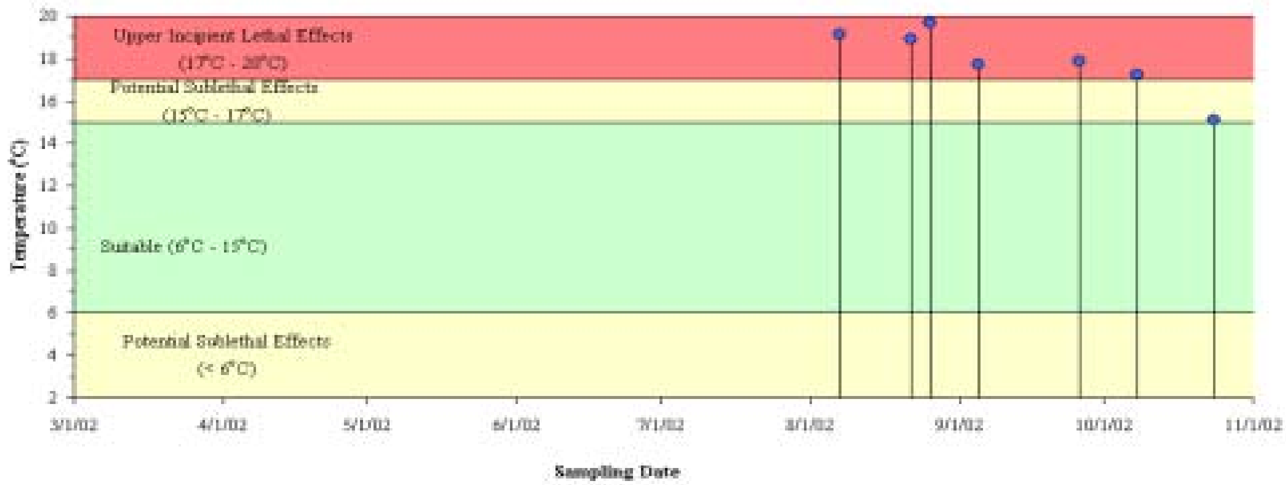

Figure B-15. Water Column Temperature at Feather River at Star Bend.

Feather River Near Verona
N --º --' --" W ---º --' --"
Pool 4-5

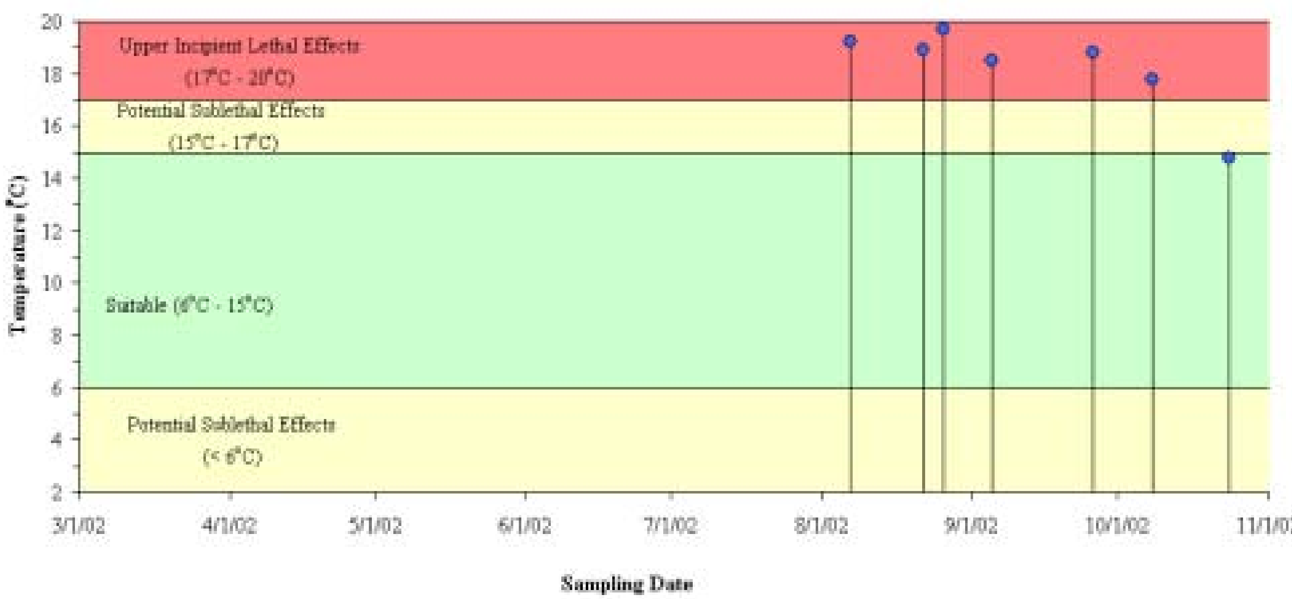

Figure B-16. Water Column Temperature at Feather River Near Verona.